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BIOMETRIC SERIES VIII

A MONOGRAPH ON ALBINISM IN MAN

BY
KARL PEARSON, F.R.S., E. NETTLESHIP, F.R.C.S., F.R.S.
AND
C. H. USHER, M.B., B.C. CAMB.

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PROVISIONAL PREFACE, PART II.

IN issuing Part II of our *Monograph on Albinism in Man*, we are very conscious of the criticisms which may at once be made with regard to it. It will be asserted that the major portion of this section deals with albinism in lower forms of life and not in man. The reply we have to make to such criticism is of a two-fold nature. In the first place, during our five or six years' work on this subject we have learnt how difficult it is to obtain material bearing on albinism of the eye and internal organs in man. Progress would be indefinitely delayed if we had to wait for full knowledge on these points until ample material in man solely was available. We have therefore sought to study the albinotic eye in the lower mammals and birds, and have bred albino dogs, that we might be the better able to ascertain the degrees of ocular albinism and of granular pigmentation in the internal organs. We have endeavoured to use this material so as to throw light on the sparse data we have been able to accumulate with regard to man himself. In the second place it has been suggested that the nature of albinism in man is different from that of albinism in various lower forms of life; that one law of heredity may hold in one case and a different law in a second. We cannot find any confirmation for this view; not only in man and dog, but in cat and bird we find a wide range of almost every grade of pigmentation in the eye, the hair or coat and the skin, and it is almost impossible to fix a limit at which albinism begins and normal pigmentation ends. Both in man and dog cases of complete albinism of the hair or coat may exist and practically escape notice because they are not associated with any, or with any nearly complete, albinism of the eye. It is only by a very full study of albinism in the lower forms of life that we can hope to interpret the variety of cases of incomplete and partial albinism in man which are slowly being linked by this study into a related whole.

The second criticism will no doubt turn on the disjointed character of this section of our work. We admit it fully. Nearly the whole of the present section is occupied with original researches. These researches have been carried out not only by the authors themselves, but by distinguished specialists who have reported on material which we have placed before them. We have made no endeavour to weld this mass of new facts into a homogeneous whole. We have allowed those who have so readily given us the aid of their trained specialist judgment and unique powers of manipulation to speak directly to the reader, and thus there can be no question whether any *à priori* opinions of the authors, if such indeed exist, have influenced in any way the description of the facts reported. In precisely the same way the several portions of this monograph which turn on the special work of one or other of its three authors are reported practically in his own words. The loss of homogeneity is thus obvious, but it is largely compensated for by the fact that independent investigations into a wide field have been united into a single volume, and that on the whole they tend to demonstrate the common features of albinism in various living forms and the innumerable grades of albinism in all of them.

Of the remaining portions of our Monograph Part IV. Text and Atlas has been long in type, so long that a large amount of fresh material has collected in our hands, and we have been obliged to add *Extra Pedigrees* and *Extra Pedigree Plates*; in addition we have felt it desirable to add supplementary Bibliographies. Part IV. containing the Bibliographies, the descriptions of our pedigrees—between six and seven hundred in number—and the pedigree plates is issued simultaneously with the present Part. Part III. involving a general account of previous work on albinism in animals, a discussion of the vital statistics of albinism in man, and of the relation of albinism to other pathological states as well as the final reduction of our statistics of heredity of albinism in man will we hope be ready towards the end of this year.

Towards the expenses of publication of this part—which have, owing to the costly character of the plates and printing, been very heavy—the grant made by the Worshipful Company of Drapers to the Biometric Laboratory has been chiefly contributory. Without this aid the memoir would never have reached fruition. The annual grant of £40 in aid of publication made by the University of London to the Department of Applied Statistics for the year 1913 has also been devoted to this memoir, and a gift of £50 to the same Department made by a donor who desires to remain anonymous has helped to supply the deficit. The outside world—even the scientific world—takes a work of this kind as it takes a text-book, as if it were self-supporting, and even grumbles at its cost and the delay in its production. It is ignorant not only of the expense of printing even a single colour plate of a series like the present, but of all the labour of hand and mind which has been put into the preparation of such a plate before it reaches the engraver. It is only by delay that the needful funds can be accumulated for the issue of a work which, should the whole edition be sold, will not repay 50 per cent. of its initial cost of production. This handicap of the higher research work, which appeals only to a small public and which by its magnitude and scope practically stands outside the field of action of existing scientific societies, deserves fuller recognition. That it has been partially surmounted in the present case has been solely due to the generosity of the Drapers' Company in their grants towards the research work of the Biometric Laboratory. Other scientific movements have lost much of the influence due to momentum owing to their originators having to scatter their researches in doles over a variety of transactions and journals. In emphasising our own difficulties and our gratitude for the manner of our deliverance, we believe we are speaking not personally but in the interests of science as a whole.

Our difficulties would indeed have been far greater, but for the aid placed at our disposal and the patience exhibited by draughtsmen, engravers and printers, and among these we have especially to express our acknowledgements to the staff of the Cambridge University Press, to which has been entrusted the whole of the printing and a considerable part but not the whole of the engraving; the aid thus given has been invaluable. Beyond those whose names are specially mentioned in the preface to Part I, we have to thank in addition Mr Herbert E. Soper, of the Biometric Laboratory, and Miss H. Gertrude Jones, Hon. Sec. of the Eugenics Laboratory, for pedigree drafting and for drawings of a variety of kinds indispensable to a work of this character.

KARL PEARSON.
E. NETTLESHIP.
C. H. USHER.

June, 1913.

CORRIGENDUM TO TEXT, PART I

Part I. p. 148, l. 13, *for* Plate Y (60) *read* Plate Y (80).

ADDENDA AND CORRIGENDA TO TEXT, PART II

pp. 274, 399—400. Elsching at the Heidelberg Congress (May, 1913) described the dissection of a human albino eye; there was some pigment present in the epithelium of the iris and ciliary body, and in some clump cells; there was no fovea. See *Klinische Monatsblätter für Augenheilkunde*, Bd. LI. (i), p. 697. This note has very considerable bearing on the pigmentation we have also found in albinotic dogs' and birds' eyes.

p 305, ftn. 3. Quite recently two other cases have come to our notice: (i) a Scandinavian lady, Fröken Ch., with no albinism of the eye or skin, but with hair of two kinds, one with no diffused pigment, the other with a very pale yellow diffused pigment; there were *no pigment granules in either kind*; (ii) the child J. B. G., aged 2 years, of a medical man; the hair showed very pale cream diffused pigment, but *no granules of any sort.* In both these cases the eyes were blue, but not albinotic.

p. 349. Add to the albino animals with hair examined: (xi) *Albino Kangaroo*, received Dec. 17, 1912, from Dr H. Rischbieth, South Australia. Hairs from back, ears and tail examined, no diffused pigment, no granules. (xii) *Antelope Cervicapra*, Mysore Zoological Gardens. Most of the hairs are white with colour near tip. White portion is, like the wholly white hairs which also occur, without diffused pigment and without granules. The coloured portion shows yellow diffused pigment and a very few granules (*a*).

p. 362, l. 26, *for* Jan Van *read* Ian ban.

p. 387. F (i). Complete Albino Blackbird. This bird died May 13, 1913, aged 4½ years. The description in the text was made Feb. 23, 1911. The sex was female. Both eyes were placed by a taxidermist in formalin 20 hours after death. They were transferred to 10 p.c. formalin six days after death. Macroscopically, both eyes are nearly white; nictitating membrane has no pigment; after removal of cornea, iris appears white; radial blood-vessels clearly seen in it; fundus almost white, much of retina in folds, delicate pink streaks at centre of several retinal folds; pecten very pale. Microscopical examination of one of the eyes and the nictitating membrane gave no evidence of presence of pigment. Stained and unstained sections were examined and an oil immersion lens used, but not a single pigment granule could be discovered in mesoblastic or epiblastic structures of any part of the eye. The anterior part of the eye was decalcified in a formalin and nitric acid solution. It will be seen that this is the second albinotic bird we have come across with completely albinotic eyes.

p. 504. Under XI. 42, *for* Dugald ban: albino = XII. 17 *read* as on Plate LVII. Donald ban: albino = XII. 18.

this failure may individually or collectively be associated with certain stocks, which may either show hereditary failure of one phase, of several, or exceptionally of all phases of pigment metabolism. In albinism as in many other defects we find equivalence or interchangeability of heredity. It is from this standpoint that we have considered it desirable to deal at length in this monograph with both leucoderma and piebaldism, for we are fairly confident that not only a thorough knowledge of the source and distribution of these will throw light on albinism, but that an actual understanding of the metabolic defect which is the origin of albinism would in its turn account for both leucoderma and piebaldism. We can only hope that our labour in collecting published and unpublished material in these directions will lead to a fuller recognition of the important points with regard to them which urgently need, from the standpoints of pathology, physiology and genetics, further investigation[1].

---

[1] In this chapter we have confined our attention chiefly to partial albinism of skin and hair; partial albinism of the eyes will be dealt with in the following chapter. Some remarkable cases of partial pigmentation—not incomplete pigmentation—of the hair may be noted here. Foremost among these attention may be drawn to Dr Heron's deaf mute albino, discussed in our Appendix, Fig. 649. His skin is completely albinotic; this is well brought out in the original of our photograph, Plate OO (137), where the whiteness of the boy's skin is markedly contrasted with that of the other boys in the group. In our reproduction much of this, but not the albinotic characterisation, is lost. His hair is completely albinotic with the exception of a black tuft on the back of the head (see Plate OO (138)) and a few smaller tufts, some consisting of only two or three black hairs. The albinotic hair is, when microscopically examined, absolutely devoid of pigment, but the black hair abounds in granular pigmentation. Similar cases of isolated dark hairs containing granular pigment have been found in other cases of apparently complete albinism: see for example our Fig. 41. Allied to these instances are those in which isolated pigment patches occur in the fundus, iris or skin of albinotic individuals: see our p. 6 ftn. Such cases are of extraordinary importance as indicating how difficult it is to regard albinism as the general absence of a ferment, and not as a complete or local structural differentiation which prevents the possibility of some normal metabolic process.

APPENDIX TO CHAPTER VI.

Report by W. Bulloch, M.D., on the Penis and Scrotum of a South African Native with white glans penis, although circumcised. The specimen was given to the authors by Dr George A. Turner of Johannesburg, April 6, 1909[2].

The organs are those of an adult male and comprise the scrotum and penis. Both are almost of a black colour. The prepuce had been circumcised. It was apparent that the glans penis both on its upper as well as its lower surface was piebald, *i.e.* there were black spots on a relatively colourless background. On examining the dorsal surface more closely four such spots were evident. The first began at the corona glandis over a base measuring six millimetres. From this the dark area was continued towards the median line gradually tapering to an apex six mm. from the base. Immediately at the apex the pigmented area opens into a diamond shape which projects backwards again touching the corona while it is continued towards the opening of the urethra: see Plate μ. The extreme length of the diamond-shaped area was 9 mm., its width being 5 mm. The second black spot was rounded in shape, sharply circumscribed and occupied the left upper and outer quadrant of the glans right up to the corona. The third spot, about 4 mm. in diameter, was more or less circular and occupied the tip of the penis down almost to the opening to the urethra. On the right side of the dorsal surface of the glans and lying just in front of a line equidistant between the corona glandis and the urethral opening was the fourth spot which was continued round the side of the glans and appeared as a larger area on the under surface of this part. In addition, the lower surface of the glans presented two other deeply pigmented areas, the one corresponding to the region of the fraenum and continued forward about half way to the urethral opening. The other pigmented area lay lateral to this and was both wider and longer. The lower surface of the glans presented therefore three pigmented areas of which one was median, the other two lateral. The lateral areas, unlike the median, were not continued up to the corona glandis but stopped a few millimetres in front of it, leaving in this way an unstained area. In comparison with the black penis and scrotum the condition of the glans presented a striking appearance. Dr G. A. Turner, who obtained the specimen, writes to the effect that during life the unpigmented areas of the glans were white, but that after it was preserved in formalin a change of colour took place, associated with darkening. Even after being many months in formalin the contrast between the black spots and the clear area was instantly apparent. An excessive strength of formalin had been used so that the organs were over hardened and were found very difficult to cut, especially when embedded in paraffin. For this reason the majority of the sections were cut by the gum method. They were obtained, however, sufficiently thin for use with a $\frac{1}{12}$ oil immersion lens. A disturbing factor was also encountered in a brownish deposit which occurred in the deeper parts of the sections from the prolonged use of the high concentration of formalin. With the help of Verocay's method, however, this was largely, if not completely, eliminated. Sections were made chiefly of the tip of the glans and involving the circular area on the dorsum and the spot in the region of the fraenum glandis. A large number of sections were examined, some being unstained, others stained with neutral red, or a very weak haematoxylin solution. It may be said at once that the prolonged examination of a large number of sections negatives the supposition that there is any evidence of acquired disease. Everything points to the conclusion that it is a congenital defect. The whole surface is covered with stratified epithelium, the cells of which show no pathological alteration with the exception that in certain areas they are either not pigmented at all or not to the same extent as in the other parts. With a low power it is at once apparent that the demarcation of pigmented from unpigmented areas is not so sharp as one would be led to believe from the macroscopic examination, the pigmented areas passing gradually into the unpigmented. Even after an unpigmented area has been reached we find here and there single cells or groups of cells which show a certain amount of pigment. In the pigmented areas it is found that it is mainly the basal layer of the epithelium that is laden with the colouring matter which is of a sepia brown colour. In some places the whole of the protoplasm of the cell is filled with the granules. In other places the pigment accumulation appears to have taken place mainly round the nuclei. In the deepest pigmented parts pigment granules are also met with in several of the outer layers of the epithelial cells (see Plate μ). In the cutis opposite the pigmented parts are large numbers of branched chromatophores (melanoblasts) deeply pigmented with coarse granules. In some places it can be clearly seen that these chromatophores are in actual contact with the basal cells of the epithelium. In the unpigmented areas some of the cells contain granules, but always in less amount than in the pigmented. In examining the unpigmented areas from side to side parts are reached where, even with a $\frac{1}{12}$ oil immersion lens, it is impossible to find a single pigment granule. A careful search has also shown that corresponding with the unpigmented areas there is a great diminution or total absence of chromatophores in the cutis.

---

[2] On the blackening of the *glans penis* of the negro after circumcision see the remarks of Dr Turner, p. 119, and of Dr Strachan, ftn. p. 123 of this monograph, also S. G. Shattock, "Pigmentation of the glans penis in the negro after circumcision," *Trans. Path. Soc. London*, Vol. XLIII. pp. 99—103, London, 1892. For a case of congenital leucosis of the penis of a negro: see Plate AA (45).

The origin of pigment in the skin has been the subject of extended inquiry, especially by Ehrmann, Riehl, Aeby, Karg, Koelliker and others (see Chapter IV of this monograph, pp. 183—194), and they have formed the opinion that the pigment in the epithelial cells is carried there by special connective tissue cells (chromatophores) which wander up to or actually in between the epithelial cells to supply the pigment. The non-pigmented areas with defective chromatophore accumulation in our specimen might be taken to favour this view. But as it has been indicated in dealing with this subject, this is to interpret an association as a certain causation, and later writers have brought strong evidence to show that pigment can be produced without the transfer by aid of chromatophores.

CHAPTER VII.

THE ALBINOTIC EYE (MAN).

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Section I. *Some Anatomical Considerations.*

Perfect or complete albinism of the eye may be defined as existing in those cases where the eye structures are entirely devoid of pigment. Such cases can readily be illustrated by the microscopical examination of the eyes of albinotic animals. In a perfectly albinotic mouse for instance the choroid, ciliary body and iris, and the layer of cells lining the inner surface of the choroid (hexagonal epithelium of the retina) and continued, as a double layer, over the ciliary body and over the back of the iris, show no trace of pigment, though all these parts in the ordinary mouse are densely pigmented and appear black or very dark brown under the microscope. Only a very few albinotic human eyes have hitherto been examined anatomically and in all of these either the albinism or the examination appears to have been incomplete; we do not know of a single exhaustive microscopical examination of a perfectly albinotic *adult* human eye. When albinism is either general but imperfect, or partial, the pigments of the eye may be entirely absent, or may be present in varying subnormal quantity; and such subnormal pigmentation may affect the whole or only part of the ocular tract.

A few words of explanation may be given here as to the pigmented parts of the eye. For the convenience of readers who are not familiar with the subject Plate γ has been prepared and a description is given in the footnote below[1]. These structures

---

[1] Description of Plate γ.

Fig. 1. A simplified diagram of the lower half of the right Human eye to show the pigmented structures in reference to Albinism. The globe as a whole is magnified about 10 diameters, but in the R. or temporal half of the Figure (marked T.) the thickness of the choroid, retina and pigmented epithelium is very much exaggerated in order to facilitate reference. In the L. or nasal half (N.) the proportions are approximately correct.

C. Cornea.

Cil. Ciliary body consisting of *c.m.* ciliary muscle, *c.p.* ciliary processes, *r.e.* double layer of epithelial cells forming the anterior and rudimentary representative of the retina. The outer layer of *r.e.* is pigmented.

Ch. Choroid, containing elongated, branched and flattened pigmented cells, principally in its outer layers. The choroid contains an enormous number of blood-vessels but these are not shown.

I. Iris consisting of *i.* fibrous structure, the iris proper, containing in most eyes a larger or smaller number of pigmented cells. *m.* muscular fibres forming a ring around the inner (pupillary) border. When this sphincter muscle *m* contracts the iris is stretched and made thinner and the pupil diminished in area. *r.e.* double layer of epithelial cells continuous with *r.e.* of the ciliary body, but both layers densely pigmented. The cells of the anterior layer are thinner and flatter than those of the posterior layer. At the pupillary border the two layers join and stop.

L. Crystalline lens.

O.N. Optic nerve showing central canal with blood-vessels on their way to the retina. The ocular end, or head of the optic nerve, within the eye, where it expands into the retina, is the optic papilla or optic disc.

P. Pupil.

R. Retina consisting, from without inwards, of *r.e.* single layer of pigmented cells, the pigmented epithelium of the retina. *b.* Bacillary layer (rods and cones). *c.* Ganglionic and granule layers, shown collectively by uniform cross-hatch shading. *f.* Nerve-fibre layer, continuous with the fibres of the optic are two: (1) the choroid lining the posterior part of the eyeball and continued in a modified form anteriorly as the ciliary body, which in its turn passes into the iris; (2) the pigmented epithelium formed of a single layer of cells that line the inner surface of the choroid and ciliary body and is continued from the latter on to the posterior (*i.e.* really the inner) surface of the iris where, however, it consists of two layers. The former (1) is composed of fibrous structures, cells containing brown pigment granules, numerous blood-vessels, lymph spaces, with the addition, in the ciliary body and iris, of muscular fibres which regulate the size of the pupil and alter the focus of the eye to permit of clear vision at varying distances. The latter (2) consists of soft friable cells crowded with dark brown pigment granules and rods; these cells lie between the choroid and retina, and as they often adhere more to the former than the latter, they were formerly described as the innermost layer of the choroid; morphologically, however, this layer of pigmented epithelial cells forms the outermost stratum of the retina. Of these two structures the pigmented epithelium is of much greater physiological importance than the pigment of the choroid and iris. That portion of it that belongs to the retina proper is necessary in some way for the full functional activity of the rod and cone layer, and when the pigment of this epithelium is wanting or very deficient in quantity the sight in man is always irremediably defective. The pigment of the choroid, ciliary body and iris, and the extension of the retinal pigment epithelium covering the two last named structures, make of the eye a camera obscura, and by absorbing excess of light guard the retina from exhaustion by over-stimulation, and maintain the contrast necessary for normal sight, but it has nothing to do with vision as such. The retinal or epithelial or epiblastic pigment, which is of such fundamental importance, is laid down very early in embryonic life, its rudiments being visible at about the end of the fourth week in man; it is abundant by the eighth week and perhaps fully formed by

nerve. *o.s.* Ora serrata, the place at which the retina as a light-perceiving structure ends and passes into the inner, unpigmented, layer of the cells (*r.e.*) lining the ciliary body (*Cil.*). *y.s.* Yellow spot of the retina, the retinal seat of accurate perception of form (as distinguished from perception of light and colour). Form-perception, acuteness or acuity of vision is indicated by V. (*visus*) or S. (*Sehschärfe*). The yellow spot is situated to the outer or temporal side of the optic disc almost exactly upon the horizontal bisection of the eye. *The distance between y.s. and optic disc should have been rather greater than it is on the diagram.*

Scl. Sclerotic.

Fig. 2. Iris (I. in Fig. 1) shown separately to illustrate the effect of variations of pigmentation upon its colour. The iris in Fig. 1 represents a "dark" or "brown" or "black" eye. In Fig. 2 the part *a.* is a "blue" iris, the epithelium pigmented, but no pigment in the fibrous structures of the iris; the part *b.* complete albinism, no pigment in any part; *c.* shows pigment present in the iris itself but none in the posterior epithelium—a rare condition, illustrated in Pedigree Figures 120, 445 and 446.

Fig. 3. Corresponding diagram for the choroid (*Ch.*) and retinal epithelium (*r.e.*). In Fig. 1 the choroid (*Ch.*) is represented as rather richly pigmented, though less so than in the eyes of negroes or other dark races. In Fig. 3 *a.* is the choroid of an ordinary very fair person with a very light-coloured fundus. This is the condition at birth in nearly all European infants; the retinal epithelium (*r.e.*) is pigmented as usual, but the choroid devoid of pigment or almost so. *b.* Complete albinism of choroid and retinal epithelium; no pigment in either. *c.* Choroid itself pigmented, but no pigment in the retinal epithelium; this is probably the condition in such cases as Pedigree Figures 295, 402, 410, 448 and 449.

about the twelfth week (Kölliker (1883), confirmed by later observers). It is illustrated by Dr Low's sections from fourth and tenth week foetuses reproduced in our Plate λ, Figs. (1) and (6)[1]. The pigment of the fibrous or mesoblastic choroid, ciliary body and iris is, in man, scarcely represented even at birth but developes at a varying rate and in different degrees in the first months or years of life. There is reason to think that the quantity, not the colour, of the pigment in the retinal epithelium may be the same or almost the same in all normal eyes; but the widest differences are found in the amount of pigment in the choroid and iris, just as in the hair and skin, of different races and different persons apparently of the same race. Eyes with little or no pigment in the choroid and iris usually see as well as those with much pigment but often suffer discomfort from bright light. Persons with such fair eyes are not usually spoken of as albinotic, or at most the term is used with a doubt, even though the hair and skin in them may be as fair as, or fairer than, in others who are unhesitatingly so classed. But if the retinal or epithelial pigment is also at fault so that sight is defective the sufferer is dubbed an albino even if his iris and pupil be not luminous and his hair be sandy or actually red. *The criterion of ocular albinism is lack or deficiency of the retinal epithelial pigment*, and clinical evidence accumulated during the last few years renders it extremely probable that this hypothesis if eventually verified will furnish the true interpretation of certain cases of visual defect, the nature of which has not hitherto been understood. We shall return to this in connection with Partial Ocular Albinism (p. 300).

Absence of pigment in albinotic eyes seems to have been proved by Duddell[2] who (about 1736) dissected the eyes of pink-eyed rabbits in order to discover the cause of corresponding appearances in the eyes of an albinotic boy. He "found the Choroides" in these rabbits "something of a fleshlier Red than the Retina or than the Retina of those Rabbits that have their Choroides Black which," he adds, "I compared together." He also noted that albinotic rabbits were not intolerant of light. Lecat also dissected the eyes of albino rabbits about 30 years after Duddell and observed the absence of pigment. In 1778 Van Iperen[3], a Dutch physician resident in the East Indies, spoke of the pupil of a dark race albino being of a red brown colour instead of black, and of the absence of pigment in the "camera obscura" of the eye of the human albino. Seiler[4] writing in 1833 of the white iris in the eyes of "Isabella" horses speaks of finding the pigmented ring at the pupillary border (due to the posterior epithelium), and found the pupils black: on dissection the choroid, ciliary body and substance of the iris without pigment, a result not in reality at variance with the earlier observations of Buzzi and others since he was dealing with the partially albinotic eyes of "wall-eyed" (Scottish "ringle ee") horses in which the pigmented epithelium may retain its colour although the iris and choroid are colourless[5]. Seiler also gave a coloured clinical illustration of a human albinotic eye. In 1833 Wharton Jones[1] demonstrated the hexagonal outlines of the cells or "plates" of the retinal epithelium (then regarded as forming part of the choroid), and stated that in the young human foetus, over the tapetum lucidum of animals that possess that structure and in the eyes of albinotic animals, these cells were smaller and less closely set than normally and more or less rounded in outline instead of hexagonal. In reference to this statement we may say here that C. H. Usher on the other hand has quite lately examined these cells in the eye of an albinotic man, in an albinotic rabbit and on the tapetum of a normal sheep and finds them, contrary to Wharton Jones, of normal size and shape.

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[1] Reproduced by permission from *Biometrika*, Vol. VII. Plates I and II, where they illustrate an article "Histological Examination of a Case of Albinism," by J. E. Adler and J. McIntosh, pp. 237 *et seq.*

[2] See Bibl. No. 55.

[3] See Bibl. No. 90: see also our p. 65.

[4] See Bibl. No. 201.

[5] The condition of the pigmented structures of the eye in "wall-eyed" dogs and horses is described in detail by C. H. Usher and Mr G. Coats in Chapter IX.

Buzzi was the first to dissect a human albinotic eye, his account being published in 1784. He found that he could see through the sclerotic the inverted image of an object formed on the fundus and states that the iris was thinner than in other eyes[2]. The iris was white like that of a white rabbit. On removing the sclerotic the choroid was seen to be reddish white and "extremely thin" and its blood-vessels plainly seen. No trace of the "uvea" could be discovered either on choroid or iris by any of the means he was accustomed to use for its demonstration, *e.g.* soaking in water, rubbing gently with the finger and use of a magnifying glass[3]. The retinae looked natural and the yellow spot distinct and of a clear yellow colour. He performed a number of experiments on rabbits in order to satisfy himself that the redness of the pupil in albinos was due to the blood in the choroidal vessels. He also examined the skin of the albino and failed to find the rete mucosum.

The first and still the fullest account of the histology of an *adult* human albinotic eye was given by Manz[4] in 1878 from examination of the eyes obtained *post-mortem* from a woman aged 27 who died in hospital. It was known that she had been intolerant of light and that her eyes were "peculiar" but no ophthalmoscopic examination or other clinical observations had been made. When seen by Manz after death, but before removal from the body, the irides were grayish white, not decidedly blue, and the pupils reddish. He was unable to find out what had been the colour of the irides during life, but does not feel justified in assuming that they were blue and therefore cannot decide exactly what effect the pigmentation of the posterior epithelium had upon the colour before death; but he says that really blue eyes remain blue after death. The hair of the head was "light though certainly not white" and the eyelashes "quite light yellow." The eyeballs after removal were of about the normal dimensions[5], horizontal diameter 24 mm., vertical 23, sagittal 24; cornea 11·5 mm. in vertical diameter, 13 mm. horizontal.

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[1] See Bibl. No. 202.

[2] "The sclerotic was twice as thin as in other eyes, so that the inverted image was seen through on the fundus." Possibly we ought to read "twice as translucent" for "twice as thin." On the other hand if the eye were very myopic, as is likely enough from what we know, the sclera and choroid would be proportionately thinned by the elongation of the globe whether the eye were albinotic or not. See Bibl. No. 95.

[3] "Uvea" appears to mean the pigmented epithelium.

[4] See Bibl. No. 357.

[5] The refraction of the eye can only be approximately estimated by measurements of the globe after removal from the body. The globe becomes more or less flaccid some hours after death, and an error of only 1 mm. in its antero-posterior diameter corresponds to a difference of about 3 dioptres in the refraction. Thus if 24 mm. be the measurement in an emmetropic (normal) eye, 25 mm. would mean myopia of about 3 dioptres, *i.e.* a moderate degree of shortsightedness.

On opening one eye in the fresh condition Manz found that the inner surface of the choroid and the retinal epithelium looked colourless to the naked eye, and the situation of the yellow spot was distinguishable only as a small fold in the retina without any special colouring either in the retina or choroid. After the eyes had been hardened, however, the inner surface of the choroid with the retinal epithelium was seen to be not quite colourless but of a light brown tint. Microscopically a sharp distinction was found throughout the whole eye as regards pigmentation, between the choroid, ciliary body and iris, none of which contained a trace of pigment, and the retinal epithelium which was pigmented in its whole extent, from the fundus forward to the back of the iris; a contrast that, the author remarks, emphasized in his mind the complete genetic difference between the two structures. The quantity of pigment in the epithelial layer was, however, much less than in a normal eye, and less in some parts of the tract than in others: thus at the fundus the amount of pigment granules was so small that the nucleus of each individual cell was visible and in many cells colourless protoplasm could be seen between the pigment grains; towards the ora serrata[1] the pigment was even more scanty than at the fundus, but in front of the ora, *i.e.* on the ciliary body, the cells were rather more pigmented, whilst at the root of the iris, where the ciliary body ends, the pigmentation became quite suddenly considerably increased and the individual cells on the back of the iris were "stuffed full of pigment grains by which in many the nucleus is obscured[2]." The cells on the iris were larger and less regularly disposed than on the ciliary body, but the normal two layers could not be demonstrated. The stratum as a whole was thickest at the central zone of the iris, rather less at the periphery and only about half the maximum at the edge of the pupil. Another feature noticed by Manz in this specimen, and regarded by him as additional evidence of defective development, was that in detaching the anterior part of the choroid from the sclera he found that a portion of Descemet's membrane and of the ligamentum pectinatum, together with part of the ciliary muscle, came away with it as is not the case in a normal eye. He regards this as showing the persistence in the fully grown, but poorly developed, albino eye of an anatomical condition which, as had then been recently described in the embryos of animals of various classes by other investigators, had proved the participation of the choroid in the formation of the deeper layers of the cornea. In addition to this easy separability of the *processus Cornealis Chorioideae* Manz instances the occasional persistence of the foetal down upon the skin, and of the pupillary membrane in the eyes of albinos, as well as the marked thinness of the sclera noticed by Buzzi[3], and the fact that albinos are sometimes the product of rapidly succeeding pregnancies, as evidences that albinism is a consequence of checked development of the foetus. Although arrest cannot be explained so long as the process of pigment formation in the organism remains unknown he thinks that it may be due to disturbance of nutrition in the mother, or to conditions of the placental or even the foetal circulation[1].

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[1] The ora serrata marks the anterior limit of the retina as a light-perceiving structure; in front of this line it becomes rudimentary. See Plate γ, *o.s.*

[2] Even this amount would be much below the normal; in a normal human iris the nuclei of the uveal cells are completely hidden by the densely crowded pigment granules.

[3] See, however, note at foot of p. 271 *supra*.

Quite recently a perfectly albinotic human infant[2] has been exhaustively examined after death[3]. At the *post-mortem* examination the thymus was enlarged, foramen ovale not quite closed, ovaries enlarged and cystic, and there was bronchitis, but all other parts looked natural. All the organs were examined microscopically and—except that not a trace of pigment could be found on careful inspection under high powers in any of the structures that, later in life, contain pigment in normal persons—no morbid changes were found. The total absence of pigment from the eye[4] enabled the structural details to be particularly well seen, as in the eye of the albino rabbit. Owing to the impossibility of obtaining the eyes quite fresh the rods and cones did not show well, but the other retinal structures were well displayed. It is probable, as the authors suggest, that this child would have remained a perfect albino if she had lived; it should however be remembered that even in normal infants the iris and choroid contain little if any pigment at birth[5] and for some months afterwards[6].

In our Plate I, Fig. 2 gives the pedigree of a remarkably perfect albino (V. 5) from whose L. eye a portion of the iris was removed by E. Nettleship in the usual manner during the operation for extraction of cataract at the age of 74 in 1888. Sections of the iris were made by Mr Kenneth Scott, and from one of them Plate *a*, Figs. (i) and (ii) have been drawn. The specimen is imperfect, doubtless owing to the operative manipulation, but traces of both layers of the retinal, or uveal, epithelium—the cubical and the flat cells—remain, and are seen to be absolutely without pigment. The iris itself is also quite pigmentless; it is thinner than a normal iris, but whether this is the result of albinotic imperfection, senile atrophy or merely of stretching at the operation cannot be decided[7].

In Plate XXVII, Fig. 256, III. 12 was an albino (Wm. Bowie) who died at the age of 67, about a fortnight after a perfectly successful operation for senile cataract by C. H. Usher in 1905. He has made a careful microscopical examination of all parts of one of this patient's eyes, and an account of the appearances with illustrations was recorded in 1906[1]. Further details have been added since. The eye was removed 11 hours after death and preserved in 5 p.c. solution of formol. When opened the situation of the yellow spot was shown as a fold, the convex surface of which projected forwards[2] and showed quite distinct yellow colouring. The fovea centralis itself was not identified in any of the microscopical sections (made in paraffin), but several of them came very close to it: the cones, and the rods in sections showing them, were, as was to be expected in a *post-mortem* specimen, lacking in plumpness and regularity of arrangement, but were of full length and thickness, *i.e.* did not suggest any such defective formation as has been found by Fritsch (see below). There was a small quantity of pigment in the choroid close to the yellow spot and in sections at some distance from it, but the pigment was limited to the deepest part (Plate *a*, Figs. (iii) and (iv))[3], and at the periphery, near the ora serrata, where the choroid was thinner, only a cell here and there contained any pigment whatever; the ciliary body and iris showed not a trace of pigment. But pigment was present, though in far less than the normal quantity, in the cells of the whole extent of the pigment epithelium on the back of the iris (two layers), inner surface of ciliary body and outer surface of retina; it was brown, was most abundant on the back of the iris and least so in the cells of the true retinal portion, but was not dense enough anywhere to prevent the nuclei of the cells from being easily seen between the pigment granules. It may be observed that the pigment epithelium of the iris is, normally, the most deeply pigmented portion of the whole eye[4]. This man's irides were recorded as clinically "blue"; but although the lens was cataractous a marked red reflex appeared in the pupil and through large areas of the iris when light was focussed on the sclerotic. Macroscopically, the iris viewed from behind was light brown; the ciliary body was purplish, especially at the circles of the ciliary processes and ora serrata, and fine lines of pigment joined these two circles (crests of the folds of the ciliary body).

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[1] See our pp. 169, 173, 182, etc.; the inheritance of albinism through the male appears, however, to be hardly consistent with this view.

[2] See Fig. 644 in which this child is shown as IV. 17.

[3] J. E. Adler, F.R.C.S., and J. McIntosh, M.D., *Biometrika*, VII. p. 237 (Part III. April 1910). On p. 237 the child's age is given as 10 weeks, but on p. 238 the body is described after death as appearing like "that of a well-nourished female child of about six weeks."

[4] The appearances of the iris, choroid and retina in this child's eye side by side with those from a normal child of same age are well shown in Plate λ, Figs. 3, 4, 5, 6; and the condition as to epiblastic (retinal) pigment in the human embryo at 4th and 10th week from sections kindly furnished by Dr Low (Aberdeen) in Figs. 1 and 2.

[5] The authors' statement (at p. 241) as to change in colour of the iris during the first year of life needs modification. The eye of the infant becomes darker during the first months or year of life if pigment developes in or upon the stroma of the iris, *i.e.* if the iris becomes brown. But it becomes lighter, blue or gray, with age, if no stromal pigment is formed.

[6] This is true of Europeans; we are not yet in a position to speak positively as to dark races.

[7] This is the specimen mentioned by Treacher Collins in his *Researches into the Anatomy and Pathology of the Eye*, p. 49 (1896). (E. N.)

In Plate XIV, Fig. 95, II. 11, John Robertson, was an albino on whose L. eye at the age of 75 C. H. Usher operated for cataract with very good result, and sections of the piece of iris removed were afterwards cut (in paraffin). They show, as in the previous case, no pigment in the proper tissue of the iris, but considerable pigmentation of the posterior epithelium in both its layers. Clinically this iris was of a light gray colour, not a good blue, and Mr Usher tells me he was much surprised to find so much pigment in the two layers of epithelial cells, as he had expected to find much less or none at all. The fundus of the other eye was visible and typically albinotic.

In regard to the retinal structures, there appears to be some doubt about the condition of the yellow spot area in the human albino. In 1838 Carron du Villards[1], in conjunction with Rolando, examined two human albino eyes which had been preserved for eighteen days in brandy ("eau de vie"). On opening one of them and looking for the yellow spot no trace of it could be discovered, although the yellow spot was recognised at once in some normal control eyes that had been lying in alcohol ("esprit de vin") for several months. The choroid in the albinotic eye he describes as resembling in appearance a well-injected intestinal mucous membrane; the posterior surface of the iris had the same appearance and the ciliary processes were like the toothed petals of a rosy flower. The promised microscopical examination of this interesting specimen and its fellow eye does not seem ever to have been published. Manz (*supra*) also observed no yellow colour in the macular region of the retina in his specimen. More recently Fritsch[2] found the fovea imperfectly developed with cones much below the normal diameter in the retina of an albinotic Herero from S.W. Africa, whilst macroscopically the yellow spot could not be distinguished. On the other hand we have seen that in Buzzi's and Usher's specimens the yellow colour of the macula was conspicuous and in Usher's the cones were apparently normal.

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[1] Usher, Bibl. No. 543, p. 248.

[2] The conversion of the concavity of the yellow spot into a convexity—a sort of invagination of the retina at that situation—is very common in eyes removed *post-mortem*, and even in eyes removed during life if preserved in formol.

[3] Reproduced, by permission, from *Transactions of the Ophthalmological Society, loc. cit.* Bibl. No. 543.

[4] Treacher Collins, *loc. cit.* p. 51.

SECTION II. *Characters of the Living Albinotic Eye.*

Clinically a human eye is called albinotic when, in a good light, the pupil is red instead of black and the iris sufficiently translucent to look red or reddish-gray. Owing to lack of pigment in the eye light passes so freely through the iris and the uncovered parts of the sclerotic and its underlying ciliary body as to illuminate the background of the globe, and after reflection be received by the observer looking, without instrumental aid, at the front of the eye. The red colour is due to the blood circulating in the choroid. Careful inspection of the iris itself in such an eye by means of light concentrated upon it obliquely by means of a lens will show that its true colour is a pale whitish gray, or even white, sometimes with a suggestion of pinkish yellow due chiefly to the blood in its own vessels. If the examination be made in duller light the appearances will be somewhat different; the pupil will still glow red in some degree, but the iris, though containing no pigment, may absorb so much of the light returning from the back of the eye as to lose its red appearance. In such circumstances the iris will look of a more decided gray or pale bluish or even violet colour. Moreover as the human iris is thicker at its pupillary than at its circumferential part, possesses visible fibrous strands radiating from the pupillary zone outwards, and also certain fissures and depressions or crypts where its structure is thinner, we can readily understand that although entirely devoid of pigment the albino iris will be more translucent and "red" to transmitted light in some parts than others, and more decidedly white, gray, bluish or violet to reflected light according to the part under inspection.

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[1] See Bibl. No. 218.

[2] Gustav Fritsch, "Vergleichende Untersuchungen der Fovea centralis des Menschen." (Vorläufige Mitteilung.) *Anatomische Anzeiger*, Bd. xxx. S. 462—4, 1907 (pp. 462—464).

Further, if viewed by a mixture of transmitted and reflected light, we shall get a combination of red with white and gray or purplish. Lastly, the general thickness of the iris probably varies in different individuals of the same age, and it no doubt increases up to a certain age with the growth and development of the body generally; whilst there are decided individual differences in the closeness of its fibrous texture. Whether an iris of maximum thickness and close texture but entirely lacking in pigment may be so nearly opaque as to transmit no perceptible light from the interior of the illuminated eye is we believe an open question; but cases are described that may be of this nature[1]. Its colour in such case would be white or nearly so, unless its intrinsic blood supply were sufficient to impart a slightly pink tinge[2]. The thickness of the iris of the same eye varies with its breadth; the broader the iris the greater, other things being equal, is its translucency; when narrowed and thickened by dilatation of the pupil the iris of an albinotic eye allows less light to pass through. Thus in the case of an incomplete albino boy whom E. Nettleship saw at the age of 11 in 1893 (Master B., P. 26, 232) and again when he was 17, he noted on both occasions that the irides were very translucent when the pupils were small but much less so when narrowed and thickened by the action of atropine used in order to dilate the pupils. The same observation has of course been made by others. See Sachs's case (1812) p. 286 below.

These various difficulties and discrepancies in relation to the colour of the albinotic iris and the actual differences that occur between various cases were fully and carefully gone into by Manz in his classical paper (1878). They had been the cause of divergencies between some of the earlier writers (Sachs, Voltaire, Maupertuis, Deschamps and Michaelis). A good illustration is one given by Cornaz, 1855[3] (his Case XV); describing the eyes of a female albino child a few months old he says "iris d'un bleu clair, mais offrant vers la circonférence de son grand cercle, un reflet assez prononcé, comme le chatoiement de certaines étoffes, tandis que la petite circonférence du diaphragme irien était fort pâle et presque blanchâtre: le fond bleu de ce voile est recouvert de nombreuses fibrilles blanches, disposées en rayon: l'ouverture pupillaire présente un aspect rougeâtre et brillant, analogue à celui d'un rubis." When the child was 5 years old the pupil was still intensely red, the inner circle of the iris still grayish white with white fibrils radiating from it and for the most part disappearing before they reached the circumference, and so numerous as almost to hide the grayish blue colour of the iris; the latter becoming darker towards the circumference where it turned to a sort of violet, which became a dull rose colour when examined by daylight. During the five years the hair, lashes and eyebrows had changed from being white at the first examination to a light blond, the lashes remaining almost white.

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[1] Manz (Bibl. No. 357) in 1878 was of opinion that the decrease of the "shining," *i.e.* red appearance, of the albinotic pupil could be adequately explained by such a normal thickening of the iris tissue without having recourse to a belated deposit of pigment.

[2] Broca (1864) had already pointed out the influence of texture, as apart from pigmentation, upon the colour of the iris. See Bibl. No. 295.

[3] See Bibl. No. 256, p. 389.

The redness of the pupil of an albino child is occasionally recorded as having given place to the normal black with increasing age and the iris, which had been translucent, as becoming darker, or pure blue, and opaque; and it is comparatively common for the very fair hair of many almost completely albinotic children to become several shades darker when they grow up. Wilde[1] saw an albino, aged 3 years, with violet-red pupils, light lilac blue irides and hair of a dirty cream colour; several years later both the hair and irides had gone considerably darker so that the latter were now "What would be termed light blue"; and he mentions a case by Ascherson in which the light blue-gray iris of an albinotic infant had become cherry brown at the end of the seventh year. The change of the pupil from red to black is illustrated in our cases Fig. 21, IV. 2, and Fig. 134, III. 3, and is probably much more frequent than our records indicate. A similar progressive pigmentation not only of the hair but of the choroid and fibrous structure of the iris is an everyday occurrence in ordinary fair children who are not classed as albinos. It is very doubtful however whether such darkening of eyes or hair from pigment formation in after life ever occurs in perfect albinos; a trace of pigment must probably be present at birth in order that any progressive pigmentation may occur afterwards. This was the opinion expressed by Wilde, and it seems to be confirmed by our own cases, *e.g.* in Figs. 20, 28, 29, 30, 95, 137 and many others[2].

In regard to the increase of ocular pigment that, as just stated, appears to occur in many incomplete albinos, we have still a good deal to learn, and we especially need proof that such increase can occur also in the choroid, ciliary body and iris proper, and in the totally distinct retinal and iridial epithelium. Also with regard to each of these structures we want to know how far an increase of pigmentation may be limited to some one part, *e.g.* the choroid or some region of it, or the retinal epithelium covering some one district, without participation of the whole tract. We believe that the change in colour of the iris in albinos, when it occurs, is usually from the translucent pale gray to pale true blue, and that this is explained by the combination of increased thickness of the iris with augmentation of pigment in an already slightly pigmented posterior epithelium. There is no difference in kind, but only in degree or density of pigmentation of the epithelium, between the blue iris of an incomplete albino and the similar blue of a normal fair person. The blue is due in both cases to the superposition of a translucent white structure over a dark stratum, not to the presence of blue pigment. The thicker such an unpigmented iris is, the paler will be its blue colour, and if thick enough it will be white as in "wall-eyed" animals. The effect may be fairly well imitated by placing sheets of white paper of various thickness over a black surface. If therefore the term white is seldom used without qualification in describing the iris of human albinos it is merely because the iris in them is seldom thick enough. We have one case, however, sent to us by Dr Grossmann of Liverpool, and given more fully at p. 299 (5), in which the iris is described by the author as white. And in the case of the celebrated mathematician Cardan, given Bibl. No. 28, "white eyes" may have meant "white irides," though it is almost as likely that he used the term in a more general sense to include pale iris with white eyelashes and eyebrows—the white *facies* of the albino. If greater density of the iris texture, rather than an increase of thickness, is the main feature, the colour will be more gray than blue. When yellow or brown pigment is deposited on the iris of an albino eye the general effect is more or less green or yellowish brown according to the quantity and tint of the pigment[1]. When the pigment is scattered in the deeper part of the iris it must be supposed to show chiefly by deepening the gray colour, or changing it to brown[2]. If we can judge from the frequency with which the irides in pronounced albinos of European races are recorded as "blue" or "light blue," *i.e.* as backed by a more or less pigmented epithelium, the conclusion must be that the posterior pigment epithelium of nearly complete albinos not infrequently grows darker with years, but that deposit of colour in the iris itself in them is uncommon. The irides of albinos of dark races very often show yellowish or brown pigment and this, together with the pigment in the posterior epithelium, is often sufficient to render the whole iris opaque. But observations are wanting as to whether any of these were quite unpigmented in early life[3].

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[1] See Bibl. No. 285.

[2] Whatever may be true of the eye—see our p. 278—with regard to the hair we may note that the hair of IX. 8, Pedigree No. 364, which contained less granular pigment than may be found in most albinos' hairs, has very sensibly darkened after four years' interval, but still no granular pigment is practically discernible.

The above remarks as to alteration of colour in the iris and change of the pupil from red in early life to black at a later period apply as already stated to cases in which the albinism was probably never quite complete. Whether a perfectly albinotic eye, an eye without a trace of pigment in any part at birth, can ever develop pigment in after life we cannot say; the point deserves careful attention, but cannot be settled by clinical evidence only since the absence of any trace of pigment can only be affirmed after microscopical examination.

Summary as to the Iris and Pupil. From the foregoing it appears that, making due allowance for the personal equation in different observers, the colour of the iris in albinos is affected to a considerable extent by the brightness of the light under which it is examined, by the direction of the light—transmitted or reflected or both simultaneously, by the thickness of the iris and the closeness of its texture, and thus in some degree by the size of the pupil, and by the presence in many albinos of some, though less than the normal, pigment in the posterior epithelium, and the presence in many albinos of dark races but much less frequently in those of European stock, of some pigment in the iris itself. It is possible, though as yet unproved, that the iris, ciliary body and sclera in an albinotic eye may sometimes be collectively opaque and the pupil consequently black from simple thickness and density of texture without the existence of any pigment. Examples of albinism in which the iris itself, apart from its posterior epithelium, was at first colourless and afterwards showed unmistakable pigmentation are believed to be uncommon, and any such should be carefully recorded in future; Ascherson's case mentioned by Wilde (*supra*) may have been such an one[1].

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[1] European albinotic eyes with pigmented iris but posterior pigment lacking are described in our Pedigrees Nos. 120, 244 (?), 445 and 446.

[2] Manz, Bibl. No. 357.

[3] The interesting account of the eyes of a Dahomey negro provided by Mr Bishop Harman should be consulted: see our p. 133.

The fundus of an extremely albinotic human eye when seen by means of the ophthalmoscope has a pale, bright red colour, orange-red would perhaps be more correct. The individual vessels of the choroid are seen with the greatest ease separated by the white sclerotic and more sharply defined than in the fairest normal eye owing to the absence in the albino of the veil interposed in the normal eye by the pigmented retinal epithelium. The only part of the albinotic fundus where the choroidal vessels cannot be seen separately as a rule, except in myopic eyes, is at the central or yellow spot area; here the large vessels are so numerous and crowded, and the capillary network so fine, that altogether the vessels in this region form a velvety-looking red screen that obscures the sclerotic. If there is much myopic stretching, however, this dense area will, as in ordinary eyes, be opened out and the separate choroidal vessels be correspondingly visible. The velvety appearance will be more marked and somewhat darker if the albinism be not quite complete, a certain amount of pigment being present in the choroid and retinal epithelium; in fact one cannot tell by ophthalmoscopic examination alone whether there are traces of pigment or not. The diffuse yellow colour of the retina at the yellow spot, although not recognisable as such in ophthalmoscopic examination, must contribute a little to darken and unify the colouring. The retinal vessels have their usual course and appearance. The optic disc appears both darker and redder than in the normal eye—an effect of contrast with the extremely pale surrounding choroid; indeed the disc is often actually the darker of the two, although not really darker than normal.

The want of pigment is not the only imperfection from which the albinotic eye suffers. A large majority of albinos when they are old enough to come under notice are found to have a considerable error of refraction, either hypermetropia (the antero-posterior axis of the eye too short), corrected by convex lenses, or myopia, short-sight (antero-posterior axis too long), corrected by concave lenses; and each of these conditions is usually complicated with astigmatism (due to the curvature of the cornea not being the same in all meridians but greatest in some one, usually the vertical meridian, and least in the one at a right angle thereto). The astigmatism often reaches a considerable, even a high, degree. The hypermetropic formation, indicating an undersized eyeball, may be indirectly connected with the fault of development, whatever it be, that leads to absence of pigment formation. The myopic elongation may be attributable to causes similar to the causes of myopia in normally pigmented eyes but operating with greater intensity, such as the habit, acquired very early when the sight is defective, of holding objects very close to the eyes. All albinos with poor vision learn this habit whatever their refraction, but all do not become myopic; we must therefore suppose that when myopia ensues it is as the result of an inborn weakness of the sclerotic which disposes it to yield, where not supported by the muscles, to the combined normal pressure of the ocular muscles externally and the intraocular fluids within[1]. In this connection we may recall that Manz (*supra*) found what he considered as microscopical evidence of immaturity of the parts at the sclero-corneal junction in his specimen. We have to assume a similar weakness either of texture or thickness as a predisposing cause of myopia in normally pigmented eyes, and it is this character, not the myopic conformation of the eye itself, that is hereditary. There is nothing far-fetched in the assumption that such defect of quality in the sclerotic is likely to be greater both in frequency and degree in albinotic than normal eyes, and although we cannot at present either refute or confirm this hypothesis it will be supported if analysis of cases should show, age for age, a considerable excess of myopia, either in frequency or degree, in albinos. It is more difficult to explain the extreme frequency of astigmatic asymmetry of the corneal curves in albinos; indeed no satisfactory account seems to have been given. Astigmatism of exactly the same kind is common in normally pigmented eyes with a perfect retina[2]; but it appears to be both more frequent and of higher degree in albinos. Perhaps an inborn weakness of the cornea, like what we have assumed for the sclera, may be at the root of the matter. That the resisting power of the cornea may vary in different persons is shown in the disease called conical cornea; here the infero-central part of the cornea, a part unsupported by the eyelids when open, very slowly yields, stretches and takes on an irregularly conical form. This disease is of course only mentioned by way of illustration; it has no relation whatever to albinism; but it occasionally affects more than one of a family. The astigmatism in albinos has been attributed[3] to the moulding or "crushing" effect of the eyelids upon the cornea, kept spasmodically half-closed as they usually are in albinos, aided by the coordinate contraction of the external muscles of the eye and even of the face. If this be true we should expect to find little or no astigmatism in albinotic infants, for such pressure would act gradually, and for the most part whilst the cornea and eyeball were still growing[4], and the astigmatism should increase steadily for some years, indeed according to Gould such an increase of the astigmatism with age does actually occur in many albinos.

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[1] Other asserted cases of change in eye pigmentation will be found referred to in our footnote 3 p. 168.

Accurate information bearing upon these points is very scanty at present and the following cases are all we can contribute. They do not at all strongly support Gould's contention.

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[1] The normal intraocular pressure is equal to about 25 mm. of mercury. Parsons, *Pathology of the Eye*, Vol. III. Part 1, Chapter XX. (1908).

[2] Parsons, from a wide literary survey, concludes that the ordinary astigmatism must be regarded as a congenital anomaly, but states that lid pressure has been shown by several investigators to be capable of causing alteration of the corneal curvature, and that even stretching the lids with the fingers can effect considerable change in the cornea. (All ophthalmic surgeons know that astigmatic patients often discover for themselves that they can improve their vision by some particular traction on their eyelids. E. N.)

[3] See Bibl. No. 443, 1893, pp. 200—209.

[4] The human eyeball as a whole attains full size at about puberty, but the cornea reaches its adult dimensions much earlier, about the third year. Parsons, *Pathology of the Eye*, Vol. III. Part 1, p. 936 *et seq.* (1908).

In Case V. 22 of Fig. 413 Usher and Souter independently measured the refraction of a completely albinotic male infant, aged 4 months, by retinoscopy under atropine, and both found in each eye the same degree of compound hypermetropic astigmatism, corrected by +4 D. sphere with +4 D. cylinder axis vertical. This baby was one of twins. The other twin, also a male, had dark hair and no suspicion of albinism; its refraction, measured under the same conditions by the same observers five months after the examination of the albino, *i.e.* at the age of 9 months, was simple hypermetropia of 4 D. in the R. eye, and 3 D. in the L.; no measurable astigmatism in either eye. This case is very important, for unless we make the extremely improbable assumption that the muscular pressure had altered the corneal curves of the albino to the extent of 4 D. within four months of birth, the conclusion must be that the corneae of these twins were already different in their curvatures at birth.

In Case II. 5 of Fig. 309 "much compound hypermetropic astigmatism" was found at 6 months of age. Dr Gray Clegg has also (November 1908) measured the refraction of a male albino (Chadwick) a few months old and found some compound hypermetropic astigmatism axes according to rule, in both eyes, the figures being, R. 1 D. and 2 D., L. 1 D. and 3 D. This case does not appear in the pedigrees. In Case III. 3 of Fig. 115, at 15 months old, there was a moderate degree of myopic astigmatism.

On the other hand in Case III. 1 of Fig. 121 there was only 1 D. of simple hypermetropic astigmatism at 9 months old, and in Case III. 9 of Fig. 116 hypermetropia of 4 D. and 5·5 D. in the R. and L. respectively with very slight astigmatism. These include the only cases we know of in which the refraction has been at all accurately recorded in complete albinos under the age of 12 months. Several could be given at from 2 to 3 years of age.

Against the theory of eyelid pressure the following considerations may be urged:—(i) the intolerance of light and closure of lids vary in degree in different albinos without corresponding variations in the astigmatism; (ii) considerable astigmatism is found in certain persons (already indicated at our p. 270) presenting blue iris, pale choroid, defective sight and nystagmus, whom we class as partial albinos, but who show no dislike whatever to bright light; we shall consider these cases at more length below; (iii) a few well-marked albinos, some of whom suffer, or have suffered, from characteristic lid-closure, have no astigmatism; thus in 104 albinotic eyes the refraction of which was carefully determined, B. Müller[1] found nine with normal emmetropic refraction.

Amongst our cases recorded as complete albinism only the three following were proved to have normal or nearly normal refraction:

Case III. 3 of Fig. 112, a man of 35 with white hair, nystagmus and "very defective" sight, has only "slight hypermetropia." In Fig. 151 a completely albinotic boy, seen from time to time between the ages of 1 and 5 years, was found at the latter age (February 6, 1897) to have emmetropic refraction and visual acuity of only $\frac{6}{60}$ with each eye; he disliked bright light, and therefore doubtless had spasm of the eyelids; the albinism was so perfect that the edge of the lens could be seen through the iris. In Case III. 1 of Fig. 7 the refraction of a completely albinotic girl 7 years old was "slightly myopic."

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[1] B. Müller, *Zeitschrift f. Augenheilkunde*, XVII. S. 25 (1907).

Amongst the complete albinos there were only five hypermetropes proved to have no sensible astigmatism in either eye[1], and six with accurately measured myopia with or without a maximum of 1 D. of astigmatism[2]. Many others are recorded as hypermetropic or myopic, some with, others without, a quantitative statement; but all have been rejected for the present purpose in which it was evident, or probable, that the measurement of the refraction had been incomplete; only those named in the footnotes reach this standard. Doubtless there is a noteworthy contingent of albinos without astigmatism, those accepted, amounting to 11 in all, being probably a good deal under the true total; but there can be equally little doubt that considerable astigmatism is present in an immense majority of all human albinotic eyes.

It is clear from the above that the collection of larger data as to the exact refraction of albinotic eyes might throw light not only upon the nature and origin of albinism itself, but upon the causes of myopia and the origin of astigmatism in ordinary, *i.e.* normally pigmented, eyes. In the meantime the following conclusions from a comparison between our comparatively small albino material and a larger series of ordinary refraction cases, though highly suggestive, must be taken as only provisional.

i. *Numerical incidence of errors of refraction in albinotic and normally pigmented eyes; all degrees of ocular albinism are included.*

N.B. In this and the following statement hypermetropia and myopia of less than 1·5 D. and astigmatism of less than 1 D. are neglected, *i.e.* counted as normal refraction and included for the present purpose with emmetropia.

In Figs. 1 to 654 are 285 persons with complete or incomplete albinism of the eyes whose refraction is stated either accurately or approximately. Ten of these (3·5 per cent.) have less than the above stated minima of refractive error and, being counted as emmetropic, are excluded; 275 (96·5 per cent.) exceed the allowed limit of refractive error. Of the 275, 37 have simple hypermetropia of 1·5 D. or more, 50 simple myopia of 1·5 D. or more, and 188 (68·4 per cent. of the 275) astigmatism 1 D. or more.

For comparison I have ascertained the refraction in 1633 normal (*i.e.* pigmented) patients with healthy eyes seeking advice about spectacles[3]. Just 500 of these

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[1] viz.: Fig. 1, IV. 6, ♀ 32; Fig. 54, III. 2, ♀ 2½; Fig. 103, III. 1, ♂ 22; Fig. 195, III. 2, ♂ 31, and Fig. 401 II. 1, ♂ 22. (The last had 1 D. of astigmatism.)

[2] viz.: Fig. 43, VI. 5 adult ♀; Fig. 55, III. 1, ♀ 27; Fig. 102, III. 1, ♀ 9; Fig. 109, IV. 4; Fig. 177, III. 14, ♀ 6; and Fig. 371, III. 2, ♂ 5.

[3] The 1634 consists of consecutive cases as follows:—208 from the Ophthalmic Out-patients at St Thomas's Hospital, 552 from Mr C. H. Usher's Hospital practice at Aberdeen, 307 from the Moorfields Ophthalmic Hospital, for whom spectacles were specially made instead of being supplied from the ready-made stock, 567 (280 + 287) from two volumes of my private Case-books for the winter months of

(30 per cent. or say one-third) have less than the required minimum of refraction error and are therefore excluded, leaving 1133 for use.

Amongst the 275 albinos presenting more than the allowed refraction error we must strike out 82 (17 simple H., 32 simple M., and 33 As.) whose degree of ametropia, though well above the limit, was not measured accurately. This leaves 193 whose refraction was for the most part accurately determined (20 simple H., 18 simple M., 76 H. As., 79 M. As. or mixed As.; or 96 on the H. side, 97 on the M. side). These 193 albinos are available for comparison with the 1133 normals.

In comparing these two the smallness of the albino series is a drawback, for we cannot be certain that it is a fair sample of all albinotic eyes, though it probably is so. We know that nearly all albinos who come for advice have considerable refractive faults. Many go untested, either because they cannot easily get advice or owing to a well-founded belief that spectacles are likely to be of only partial use to them; but there is no reason for supposing that the refraction in them is less, or less often, abnormal, than in the ones we actually know of.

In simple tabular form the figures are as follows:

TABLE A. *Kind of Refraction.*

		H.	M.	Simple or Compound H. As.	Simple or Compound H. and M. As. and Mixed As.
Albinos (193)	Totals[1]......	20	18	76	79
	Percentages	10·5	9·5	39	41
Normals (1133)	Totals	296	232	293	312
	Percentages	26	20	26	28

ii. *Degree of the various errors of refraction in albinotic and normal eyes.* In this computation the data have been used differently: under hypermetropia are counted all eyes requiring a + correcting spherical lens whether the eye be also astigmatic or not; under myopia all requiring a − lens whether also astigmatic or not; under astigmatism all requiring a + or − cylindrical lens whether requiring a spherical + or − in addition or not. Hence some of these cases are counted twice, *e.g.* a case requiring for correction a +2 D. spherical combined with +2 D. cylindrical lens

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1890—91 and 1897—98. All except the last series were quite recent cases. The 307 Moorfields Hospital cases, being selected, contain an excess of As. and of high H. and high M. The 567 private cases were also to some degree self-selected since the proportion of well-to-do persons who buy simple spectacles without advice is probably larger than the corresponding number amongst the Hospital class. But separate computations show that the discrepancies thus introduced are not large, and the 1133 have therefore been considered as an average sample.

[1] [The statistician must bear in mind that a large number of albinos definitely stated to be myopic, but for whom no proof was given, are omitted; those included were either measured or qualitatively determined. K. P.]

appears as hypermetropic, and again as astigmatic. Nevertheless the total number of albino cases available for this return is less than the 193 used for the previous one where a certain number of only approximately accurate data were used. Only one eye of each person has been counted, viz. the one with the greater refractive error, or the myopic one if only one be myopic; but in a few cases both eyes have been counted, as when there was low M. in one and high H. in the other. Mixed astigmatism is counted with myopia. The H. and M. groups are tabulated separately, but all the As. cases, whether corrected by a + or − lens, are entered together.

TABLE B. *Relative incidence of Hypermetropia, Myopia and Astigmatism of various degrees in Albinotic and Normally pigmented Eyes.*

	Hypermetropia and H. As.						Total	Myopia and M. As. and Mixed As.						Total	Astigmatism, Simple, Compound, or Mixed						Total
	1·5 to 3 D.	3·5 to 5 D.	5·5 to 6 D.	6·5 to 7 D.	7·5 to 9 D.	10 D.		1·5 to 3 D.	3·5 to 5 D.	5·5 to 8 D.	9 to 12 D.	13 to 15 D.	16 to 20 D.		1 to 2·25 D.	2·5 to 3 D.	3·5 to 4 D.	4·5 to 5 D.	5·5 to 6 D.	6·5 to 7 D.	
Albinos (155 persons)	34	16	4	6	3	—	63	21	11	12	11	2	— 1	58	35	32	33	21	3	4	128
Percentages	54	25	6	10	5	—		36	19	21	19	—	5		27	25	26	17	2	3	
				15																	
Normals (1133 persons)	316	128	28	13	5	1	491	152	116	96	52	14	13	443	348	127	80	24	12	2	593
Percentages	64	26	6	3	1	—		34	26	22	12	6			59	22	13	4	2		
				4																	

Consideration of Table B shows in regard to H. and H. As. that the lower degrees (1·5 to 3 D.) are relatively less frequent in albinos than normals, but that in the higher degrees the proportions are first equalised (at 3·5 to 5 D.) and then rapidly increase in the albinos (14 p.c. in albinos, 4 p.c. in normals). Some of the highest degrees of H. in the albinos had no As.; thus four cases out of the 14 of simple H. had from 5·5 to 9 D.

In M. and M. As. degree for degree there is no striking difference between albinos and normals. Of the 14 cases of simple M. in albinos, six had 9 D. or more, one having 22 D. (♀, aged 15). The highest amount was seen in a ♀, 12 years old, who had M. 23 D. with 4 D. of As.; when first seen, at the age of 7, the figures were 20 of M. with 4 D. of As. Two boys of 10 and 13 years had 10 D of M.[1]

As to As. alone, we find in the first place that no less than 128 of the 155 accurately measured albinos, or 82·6 p.c., have 1 D. or more; whilst of the 1133 normals only 52 p.c. have the same. Next it is seen that, as with H., the lower degrees of As. are less, and the higher degrees much more, relatively frequent in albinos than normals. Astigmatism is therefore more frequent and of higher degree in albinos than in pigmented persons. The hypermetropic formation we are certain is present at birth, and that the astigmatism has the same distribution of relative frequency and degree, as between albinos and normals, points emphatically to its being congenital also[1].

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[1] The above, and other high degrees, are found in Figs. 43, 55, 94, 116, 118, 140, 177, 199, 212, 393.

Other factors that might disturb the relation assumed (p. 280 *supra*) between lid-closure and astigmatism might be variations of the palpebral aperture, of the conformation of eyebrows and upper margin of orbit, and of the prominence of the eyeball depending upon the depth of the orbit and length of the globe. The problem of whether albinism and astigmatism when associated are related as cause and effect or correlated to a common factor in the embryo is we think undecided, and cannot be solved until more attention has been given to the condition of the pigment epithelium in normal eyes. If it were shown that in the astigmatic persons whose visual acuteness remains subnormal after prolonged use of proper spectacles the retinal pigment were deficient, even in the yellow spot region only, an important advance would have been made; the correlation hypothesis would receive support and a group of hitherto anomalous cases of defective sight be explained. A similar defect in the pigment epithelium might even account for some few cases of inexplicable congenital amblyopia where there is no associated refraction error.

Nystagmus (rhythmical oscillation of the eyeballs) is an almost constant feature. The movements are horizontal in the great majority of cases but sometimes rotatory. The rapidity and amplitude of the nystagmus show a wide range of variation in different cases, and vary to a certain degree in the same person at different times and in different positions of the eyes, and there is often some one position of the eyes in which the movement is at its minimum, the so-called "position of rest." The nystagmus often becomes decidedly less marked as the albino grows older. In all these features the nystagmus accompanying albinism resembles the nystagmus so generally associated with defects of sight from other morbid conditions that date from birth or early infancy; the subject is pursued further at p. 292 below[2].

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[1] B. Müller, in the paper referred to p. 281 above, examined the refraction carefully in 104 albinotic eyes, and found myopia and myopic astigmatism in 83, hypermetropic astigmatism in 12, emmetropia in 9. The 104 eyes belonged to 57 persons of whom 48 were aged less than 21 years. In 24 of the 51 eyes with simple myopia (excluding the 32 with myopic astigmatism) the myopia ranged from 10 D. to 18 D. The material was collected at the Eye Hospital at Halle, and the excessive proportion of myopic eyes may have been due in part to race: Müller scarcely touches upon either heredity or mental defects, but refers to Pilcz and Wintersteiner's paper of 1904 (discussed in our Chapter XI) in which albinism is regarded as a degeneration.

[2] We have not attempted to inquire whether there may be a labyrinthine factor in the nystagmus of albinos. Although the ocular conditions in human albinos supply cause enough for the oscillation the point deserves attention, especially as albinotic cats, some partially albinotic Japanese mice (see our Chapter X) and it is said albinotic stoats are often deaf (as to stoats see letter by R. W. Jones in the *Times* of February 11, 1911).

SECTION III. *The Vision of Albinos.*

The visual acuity of albinos is almost always defective, often extremely so, and it can seldom be much improved by the most accurately adapted spectacles even when worn constantly for years.

One of the earliest observations on the quality of the vision is by Duddell who in his account of an albino boy in 1736 said that his sight was as good as that "of a great many myopes is in the Day, viz. of his Focus," but he adds that the boy had to hold his book obliquely to his head because, being unable to converge his optic axes he could use only one eye at a time[1].

Buffon described an albinotic negress aged 18, named Genevieve (see our Fig. 278) in 1777; she was "what is called short-sighted, but she could distinguish the smallest objects at two or three inches from her eyes": he continues "the most singular circumstance respecting her eyes, was a continual motion or oscillation" which he adds she was not able to stop,—clearly she had nystagmus. Her irides were "dull blue"; she had no intolerance of even full sunlight.

But Sachs (a physician who, as well as his sister, was albinotic) was the first to deal carefully with the vision of albinos (1812)[2]. He recognised that the visual imperfections and difficulties from which albinos suffer were explained in part by the excess of light that entered the eye through the semitranslucent iris causing over-excitement of the retina, partly by the lack of pigment in the choroid necessary, as that pigment was already held by some physiologists to be, for the perfect functioning of the retina. He also very acutely observed that in an albinotic eye the contraction of the pupil by light must afford less protection to the retina than in a normal eye, being counteracted in the albino by the increase of transparency of the iris that accompanies its expansion when the pupil is small. His speculations on the cause of the nystagmus in albinos though interesting were wide of the mark.

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[1] See Bibl. No. 55. Inability to converge the eyes is not the only cause of this rotation of the head in cases where objects have to be held very close. Rotation of the head is not infrequently acquired in cases of nystagmus because the oscillation is at its minimum when the eyes are directed sideways (to R. or L.), the head must then be rotated in the opposite direction in order that the eyes may be brought to look forwards and thus be in harmony with the natural position of the hands and arms.

Another reason for an abnormal position of the head and book being sometimes adopted by the subjects of nystagmus, whether albinos or not, is that some of them find they can read by placing the lines of print vertically instead of horizontally. Our portrait, Plate O (45), shows this in a striking manner; this photo was kindly procured by Dr V. Magnus, who had been asked by K. Pearson to photograph any albino reading in their habitual manner. The explanation, given long ago by Soelberg Wells (*Treatise on the Diseases of the Eye*, 2nd Edn. p. 611 (1870)), amounts to this, that if the oscillation is lateral (and this is the rule) the letters run into one another when the lines of print are horizontal, whereas when the page is held with its lines of print vertical the separation between the letters is preserved and they are thus less confused together.

An early case of this kind is that noticed by Dr Perceval in 1790 in an Irish albino girl aged 11, low in stature, healthy appearance and strong make. "Her eyes are constructed in an extraordinary manner; their motion instead of a regular horizontal one, from left to right, and *vice versâ*, is tremulous in all directions, and partly perpendicular, with a prominent motion of the globe of the eye; what lateral motion the eye is capable of is short, interrupted, and gives that organ the appearance of being bound by ligaments, from which it struggles to get free. The child cannot easily look upwards, or see any object placed above her eyes; and when she reads, which she does without any hesitation or difficulty, she reads perpendicularly from the bottom upwards, and holds the book accordingly" (see Bibl. No. 117). This case is of interest as showing that the position may be assumed even when the nystagmus is not wholly horizontal. Siebold in 1787 (see Bibl. No. 105, S. 165) had also described a youth of 17, who could recognise no letters at all when the lines were horizontal, but must hold the lines vertical to read. M. Raynaud (see Bibl. No. 190) had observed a young albino man with the same habit. And of modern instances beside that illustrated in Dr Magnus' photograph, it was on inquiry found by Dr Carment to be the custom of the albino girl V. 1 in our Fig. 484.

[2] See Bibl. No. 151.

The principal cause of the poor sight in the albino is the absence or deficiency of pigment in the retinal epithelium; or if not the absence of actually formed pigment then to lack of one of the two colourless bodies that are necessary for its production[1]. This pigment is, in some way not fully understood, necessary to the perfect functioning of the retina. In the majority of animals provided with a tapetum (but not in all) the pigment is absent from the retinal epithelium covering it and this might be thought to show that the pigment was unimportant to vision in eyes with no tapetum. We do not however know much about the visual acuteness (accuracy of perception of form) of such animals, and it may perhaps be no better on the tapetal area than it is in human albinos. We have already seen that the retinal pigment is laid down early in embryonic life and is fully formed long before birth. Whether when it is entirely lacking or seriously deficient at birth it can be gradually formed or increased afterwards has we believe not been decided by microscopical tests. The principal evidence, and it is strong, for progressive increase is the alteration of colour of the iris in some albinotic eyes from pale grayish or whitish to a real blue, a change believed to show increased pigmentation of its posterior epithelium. If a similar increase took place in the epithelium at the yellow spot region why should not the albino's sight improve much more than in fact it usually does? Granting the fact of such improved pigmentation we can only suppose that it comes so gradually and so late that the retina is no longer educable; just as it remains permanently defective in function if during earliest infancy it be excluded from vision by opacity of the cornea or lens. We must however not assume too easily that the sight never improves to any high standard in albinos, though our own experience points in the other direction; for the authors of the *Nouveaux*

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[1] Raehlmann in an important paper (*Zeitschrift f. Augenheilkunde*, XVII. pp. 1—24 (1907)) alludes to the first appearance of the retinal epithelial pigment in that part of the outer layer of the secondary eye-vesicle that is nearest to the incipient blood-channels, and holds that the pigment-forming pair of substances are derived the one from the blood (see, however, our discussion pp. 189 *et seq.*), the other from the retinal epithelial cell; the latter, the cell determinant, is visible in the form of minute granules in the cells, and similar granules are found in the retinal epithelium of albinotic eyes and in those covering the tapetum of animals that possess one. The epithelial pigment occurs in two forms in the cells, minute granules and rods, and the rods are sometimes arranged into the spindle-shaped bundles that have been described as crystals.

éléments d'Ophthalmologie[1], state that not only may the amblyopia become less as pigment developes but that a cure is almost the rule in partial albinism. In our Fig. 46[2] the V. of the incomplete albino, V. 4, has undoubtedly improved from about $\frac{6}{60}$ when he was 6 years old to about $\frac{6}{18}$ when he was about 8, and now to $\frac{6}{12}$ as Mr Leslie Paton has lately informed me (E. N. December 1908), the lad being now about 19. This improvement has taken place whilst he has been using his correcting spectacles. His nystagmus is still present.

In another case[3] however V. now $\frac{6}{36}$ has as I have quite recently heard from Mr J. F. Cunningham improved very little if at all since 1893 when the patient, at 11, began to wear his true correction; and the refraction has only altered by reduction from H. 4·5 and 6 to 3 and 4 in R. and L., the slight As. (about 0·5 D.) being unchanged. (E. N. November 1908.)

But whatever may be the truth as to the occasional occurrence of marked improvement of form-perception by the albinotic retina during the years of childhood and adolescence there is clinical evidence that decided amelioration during the early weeks or months of life is not uncommon. Mothers sometimes assure us that their albino babies seemed to be quite blind for a time and only very gradually showed indications of sight; and although we cannot without rigid proof accept the statement that an albinotic infant was at any time unable to perceive light we may believe the mother's assertion that it took no notice or lay with its eyes shut for some weeks or months after birth. We have never seen a case of this kind in which the pupils did not respond to light. The following cases are in point:

Case (1). Cornaz[4] mentions such a case seen in Sichel's hospital practice. The mother said that her female albinotic infant was "blind" for the first months of life and only began to see at seven months; Sichel himself however from the first told her that the infant was not blind. The woman judged by the baby's very pronounced nystagmus which she took as a proof of blindness; and she considered the diminution of this symptom when the first tooth appeared as a sign that the child was beginning to see.

Case (2). In 1877 Abadie recorded a case in which two albinotic siblings appeared to be quite blind for the first nine months of life, then gradually gave indications of sight, and when seen at 9 and 5 years old respectively had visual acuteness of $\frac{1}{10}$. (Fig. 74.)

About a year later (1879) Parenteau, Abadie's chef de clinique, republished these two cases and added others of the same character from Abadie's practice.

The following are similar cases from our new material, and from them it will be evident that the phenomenon to which Sichel and Abadie drew special attention is not infrequent in various degrees. It may even be suggested that the variations in the age at which normal new born infants give satisfactory evidences of sight are sometimes due to a slight temporary retardation of development of the retinal pigment epithelium[1].

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[1] See Bibl. No. 565. "Maladies de la Choroide," IV. *Anomalies*, pp. 627—8.

[2] See Bibl. No. 502 (1902), p. 115, Case 3, and Bibl. No. 543 (1906), p. 252, Case 1.

[3] See Bibl. No. 502, p. 117, Case 4.

[4] See Bibl. No. 256, p. 369, Obs. XV. The child was seen by Cornaz in 1850.

Case (3). III. 6 in Fig. 20, a perfect albino, girl, had V. $\frac{6}{36}$ with her correction when 18 years old; the history was that up to the age of 6 months her sight had been very poor but improved during the next few months.

Case (4). III. 6, in Fig. 56, a perfect albino, "did not open his eyes" for several days after birth.

Case (5). III. 9, Fig. 89, complete albino, "never looked up" in infancy, *i.e.* probably did not see enough to fix objects.

Case (6). III. 1, Fig. 121, seen when 4 months and again when 9 months old and at the latter age "still sees very badly and shows irregular purposeless movements of eyes."

Case (7). II. 2, Fig. 150, a perfect albino seen when 17 years old, was said by his parents to have been blind for six months after birth and to have had "no pupils." The latter assertion probably meant merely that there was so little contrast between the red pupil and the almost equally red (translucent) iris that the two were not distinguished, rather than, as supposed by some writers, that the pupil was obscured by the persistence of the pupillary membrane (Siebold's case, 1787).

Case (8). II. 3, Fig. 397, a practically complete albino girl aged 12, was thought to be blind for three months after birth.

Case (9). III. 3, Fig. 404, a complete albino male infant, 2 months old; "mother thinks he cannot see, but he dislikes bright light."

Case (10). A male infant aged 4 months (Robert Jones) brought to E. Nettleship at the Moorfields Hospital in November 1890, because it had never "taken notice" as the mother's four previous children did. Hair and irides very fair, nystagmus, pupils act well to light, fundi (examined under chloroform) well seen and perfectly healthy; child normal and strong. In May 1891 (aged 10 months), the child seemed to see well and picked up a threepenny-bit easily, but still had nystagmus and no change in colour of hair. In May 1895 (aged 6 years), nystagmus still present, hair had become light brown; refraction (atropine) R. H. 4 D. vertical, 7 D. horizontal, L. H. 4 and 6 D. correspondingly.

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[1] Delay in the evolution of conscious vision in infants may according to Marcus Gunn sometimes simulate blindness or amblyopia due to disease. He compares the condition to the better known "hysterical amblyopia" of later life and thinks it is caused by deferred development of some of the connections between the lower and higher visual centres. Such infants are, he says, brought for advice because the mothers think they cannot see, *i.e.* because they do not "take notice" of and follow ordinary objects with their eyes; sometimes, but less often, they seem to be deaf too. But the pupils act to light, the ophthalmoscopic appearances are perfectly natural and the child is well developed and not ill in any way. Though indifferent to ordinary objects of sight they will often cry when their eyes are shaded, wink when exposed to light and follow with their eyes the movements of a lamp, and in a few months "the child slowly seems to become awake and alive to things visible" [R. Marcus Gunn, "On the Examination and Treatment of Eye-diseases in Children," *International Clinics*, Second Series, Vol. I. pp. 182—188 (1892)]. (There is no apparent reason why Gunn's hypothesis of delayed development of the higher visual path, and the one suggested by ourselves, delayed or defective completion of the retinal pigment, should not both be true and both occur sometimes in the same infant. E. N.)

Case (11). Samuel Melloy aged 4 months, seen at St Thomas's Hospital in 1887[1]; complete albino with constant, slow lateral nystagmus, light blue irides, pupils recorded as only slightly pink, hair and eyelashes white, fundus appears normal but was not well seen. Is thought not to be able to see and in fact does not follow the light of the ophthalmoscope mirror with any regularity; but the pupils act well to light. Child seems normal in every other respect and sucks well; head well formed and of moderate size. No inquiry made about family history.

Case (12). III. 3, Fig. 573, first seen in 1889 when 9 years old and again in 1895; hair almost quite white; pupils pink, but only moderately so; irides quite gray and pupillary part yellowish; refraction, under atropine, M. 4 to 5 D. vertical, Em. horizontal, V. corrected $\frac{6}{36}$. No dislike of bright light when seen the second time, but had worn coloured glasses in earlier years. Nystagmus has been present according to the mother from birth or a few days after and "was so bad that for the first six months the child scarcely took notice." Is the third born of eight, Nos. 1, 5, and 6, all ♂ died under 12 months old, the other five living. Patient (third) is only 11 months younger than No. 2. Mother was very delicate during third pregnancy but not during the others. None of the siblings and neither parent albinotic; no other inquiries were possible.

We may conjecture that such an albinotic infant with perception, but no consciousness, of light, keeps its eyes shut in order to protect them against glare,—a subject to which we shall return,—and this very closure must of course prevent that early education of the already imperfect retina in the perception and interpretation of sharply defined images that is essential to the development of good vision even in normally pigmented eyes[2]. It seems paradoxical, but may nevertheless be true, to say that the eyes of the infant albino suffer at the same time from too much and too little light, and that its chances of improvement would be best if it were encouraged to open its eyes by keeping them *deeply*, but not *closely* shaded[3].

The albino also suffers from the excess of diffused light that, reaching his retina through the translucent sclera, choroid and iris, destroys the necessary contrast between the retinal image and the surrounding surface, as when a lantern image is thrown upon the screen in a lighted room. This of course is a relative matter and will cease to operate in cases where, and in proportion as, the ocular pigment and thickness of the tissues increase with age. Dazzling and fatigue of the retina also ensue from the same cause, and the constant effort to exclude the light leads to the semi-closure of the lids, frowning and sometimes associated grimacing, that are so characteristic in albino children and often persist through life. These difficulties are lessened by shading the eyes or wearing dark glasses; one highly talented perfect albino of whom we know, after trying all sorts of devices found most advantage in reading from the use of a closely fitting shield of blackened metal with a minute central hole or slit opposite the pupil[1]. Attempts to introduce colouring matter under the conjunctiva[2] are probably too mechanical to be safe, whilst tattooing the peripheral zone of the cornea would certainly be dangerous and not more lasting than the operation for tattooing corneal scars.

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[1] See Bibl. No. 416.

[2] Any hindrance to the formation of clear images during the early months of life, such as persistent closure of the eyelids or dense opacity of the cornea or lens, is followed by permanent defect of sight unless the obstruction can be cleared away in good time.

[3] The custom of protecting the eyes of ordinary babies from strong light probably assists the development of retinal function in the same way. It would, on this supposition, be unfortunate if the modern vogue for light and air should lead to infants being taken out of doors with the eyes exposed.

It is clear then that a distinction must be drawn between the two factors that cause the characteristic imperfection of the sight in albinos,—defective perception of form, and want of normal contrast on the retina with its accompaniments of dazzling and fatigue; and it is evident that however much the latter may be mitigated either by artificial means or gradual formation of uveal pigment, the former remains and undergoes at the best only a very partial improvement. And here we may point out that when a patient with bad sight says his sight has "improved" with years he does not always mean that his acuteness of vision has increased; it may be only that owing to the cessation of some disagreeable symptom (intolerance of light in our present topic) he is able to use his eyes with more comfort or for longer at a time, or that by practice his power of interpreting imperfect images has been enhanced, or even that he has learnt to compensate for the defect of one faculty by the unconscious improvement of others.

Let us now return to the albinotic baby. If it have any considerable error of refraction this would act as a further hindrance to vision by lowering the sharpness of the retinal images. When such an albino is seen a few years later, having learnt his letters or learnt to read, his distant visual acuity is found to be very low, from say $\frac{6}{60}$ to $\frac{6}{36}$ or $\frac{6}{24}$, seldom better, and of course much less if he is myopic to any considerable degree, and he will read print of various sizes, not usually the smallest, but the book must be held close to his face. The most careful correction of his refraction will as a rule give but slight improvement of distant vision, though he will say, and rightly, that he can see "more clearly" with the glasses; for reading, the improvement from spectacles is often more decided though very far from what it would be if only the refraction were at fault. If the patient be seen again years afterwards having used the proper spectacles according to instructions ever since, V. is generally found to be as before, sometimes better, but there is seldom any striking improvement (but *cf.* p. 287 *supra*). In children without a trace of albinism but with high hypermetropia or astigmatism the visual acuity is naturally subnormal because their retinal images are not clear and V. often cannot be raised at once to the full standard by the most accurate optical correction; but when they are seen again after having used their spectacles for months or years, sight is found to be much better and often quite up to the normal standard; the end-organs of their retina, unlike those of the albino, are perfect and practice in the interpretation of well-defined images is all that was needed to give full vision.

Ophthalmic surgeons occasionally see cases where the eyes present absolutely no signs of disease and yet are permanently defective sometimes without, more often with, errors of refraction. It is possible that in some of these the pigment of the retinal epithelium is subnormal in quantity, perhaps only at the region of the yellow spot, that they may in fact be minimal cases of ocular albinism (see Partial Ocular Albinism, p. 300 (6)). This is however a mere suggestion, and at present incapable either of proof or refutation.

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[1] This was years before Picqué in 1886 recommended a pinhole screen: see Bibl. No. 410.

[2] Komoto (of Tokio), "Ueber ein Verfahren zur Verbesserung der Sehschärfe albinotischer Augen": see Bibl. No. 556, 1907.

The nystagmus of albinos depends upon their congenital imperfection of sight and as already stated differs in no essential way from the oscillation caused by other forms of congenital and infantile amblyopia. An infant born with very defective sight or suffering from severe damage to sight within weeks or months of birth does not learn to control and direct the movements of its eyes but gets the habit of moving them aimlessly. When, as is usual, these movements are rhythmical and constant the term nystagmus is used. Nystagmus nearly always affects both eyes and is constant in character in each case, although between one case and another marked differences may be found in the rapidity and amplitude and sometimes in the direction of the movements. In albinos the oscillations are usually rapid (100 to 150 in a minute, according to the careful records made by C. H. Usher in the descriptions of many of his cases[1]), sometimes slow; usually in the horizontal plane, but occasionally rotatory. The scanty data that we have suggest that the rapidity of the oscillations tends to increase, up to a certain time, with age[2]. When sight is lost later in life after the co-ordinated ocular movements have been fully acquired, nystagmus does not ensue with nearly the same frequency and when it does occur is apt to be less rapid and less regular in rhythm and extent than when it dates from infancy. Neurologists are familiar with forms of nystagmus due to disorder of the central mechanism governing the ocular movements, without any affection of sight, one variety in infants being accompanied by similar movements of the head. Nystagmus is also seen in coal-miners and sometimes in men of other occupations, who have to work in positions that oblige the eyes to take a direction,—upwards for the most part,—for which the eye muscles are not adapted and the maintenance of which causes chronic fatigue. The oscillations in miners' nystagmus may vary in rapidity from 100 to about 350 in a minute[3]. In these groups the fault lies in the central motor mechanism or perhaps in miners' nystagmus in the muscles themselves, not in the sensory end-organ as in the class of cases first considered. In many cases of nystagmus the movement is much lessened, or may even be absent, in some particular position, generally a lateral position, right or left, and the subject often learns to turn his eyes in that direction when he wants to see to the best advantage and for convenience also turns his head in the opposite direction (see footnote to p. 286). In nystagmus dating from infancy the objects looked at do not seem to be moving, but when it sets in late, as in coal-miners, the movements of the eyes are apparent to the sufferer as a "dancing" or "spinning" or "swinging" of the object looked at, and much embarrassment results (Snell). The nystagmus with "head-nodding" in infants alluded to above forms no part of our present subject. We must however mention that movements of the head are not infrequently seen in albinos, generally small, rapid and from side to side, but sometimes less regular in rhythm and direction[1]. The movement may be absent or much lessened at one time, much more marked at another, and an albino can sometimes tell by his sensations whether his head is moving or not. We are tempted to suppose that such head-movements may be reciprocal to the eye-movements, but the motion both of eyes and head is too rapid and too small for the question to be settled by direct observation[2]. Nystagmus from albinism and other infantile defects of sight is said to be sometimes increased by other muscular actions, *e.g.* during suckling, and by exposure to strong light. On the other hand it often diminishes with age, and, although exact evidence on this point is seldom forthcoming, the statement is made so often by the patients and their friends that we cannot doubt its correctness, indeed there is sometimes a clear history that eyes now quite steady used to "shake" some years ago (Fig. 89, III. 6). Conversely the denial of nystagmus by parents and others when giving histories of their children or relatives must be accepted with caution for fine and extremely rapid oscillations may be readily overlooked.

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[1] Out of 33 cases observed the rate per minute was between 66 and 96 in 7, between 100 and 120 in 17, between 121 and 156 in 9.

[2] Of the 33 albinos with rapid nystagmus (66 to 156 a minute) only 5 were below the age of 20, being in fact between about 8 and 13 years old, viz. the 3 siblings IV. 1, 4, 5 in Fig. 109, IV. 5 in Fig. 131, and V. 6 in Fig. 368. On the other hand in 13 albinos the nystagmus is marked as "slow," one of these being 25 a minute; 4 of these 13 were infants less than 10 months old, 3 were aged between 2 and 4 years, and only 3 were over 20.

[3] Miners' nystagmus was made the subject of careful study for many years by the late Professor Simeon Snell of Sheffield and the above numbers are taken from his latest communication on the subject made in the course of his Presidential Address at the meeting of the British Medical Association at Sheffield in 1908 (*The Lancet*, August 1st, 1908). Snell's muscle-fatigue theory of miners' nystagmus is by no means universally accepted. Other authorities hold that there is also a retinal factor and appeal to the alteration in the acuteness of vision at the fovea (exact centre) and the para-foveal area, to the advantage of the latter, that is, according to W. Nagel, brought about by dark adaptation of the eye. The muscular and the retinal theory do not seem to be mutually exclusive; each may take a share.

There is at present no reason to believe that either perception of colour or of light is defective in albinos. As to the latter, perception of light and of light difference (contrast) scarcely anything is known so far as we are aware. Photometric observations are difficult to make and unless carefully carried out are apt to be inconclusive if not misleading[3]. Light sense was decidedly defective in our Fig. 401, II. 1, and the patient said he could not see at night; and in Fig. 235 one of the albinos complained of night-blindness. But although albinos occasionally complain of seeing worse by night the real difficulty in such instances may well be the mere night-awkwardness that is sometimes met with even in persons with ordinary eyes.

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[1] Head-movement will be found recorded in one or more of the albinos in Figs. 17, 36, 43, 47, 81, 114, 141, 310, 391, 448 and 449. It affected the two sexes with equal frequency. None of these head-shakers were less than 8 years old—a fact rather favouring the view that the movement is the result of an attempt to cancel the confusion of sight caused by the nystagmus.

[2] Soelberg Wells however states definitely that the head-movements are remedial and contrary to those of the eyes (*loc. cit.*).

[3] Some remarks on the question of light perception in relation to albinism may be found in a paper by Nettleship (1902): see Bibl. No. 502, p. 112.

On the other hand the intolerance of light so common in albinos leads them to prefer dull light[1], but we know of no observations showing that their visual acuity is sensibly better in such light. The careful observations by Deschamps[2] and Wartmann[3] (1848), though very interesting, are not necessarily conclusive. We know that the sensitiveness to light often becomes much less in albinos as they grow older, and that cases occur in which, if the history can be trusted, the symptom has not been present in any troublesome degree at any time of life.

Colour-perception in albinos appears to be as good as in other people, but only comparatively few had been tested before our investigations. Thus in 1848 Wartmann[3] tested an albinotic brother and two albinotic sisters aged 14, 12 and 10, and their albinotic cousin aged 5; further he tested two albinotic cousins of another pedigree aged 32 and 25 with great care, and found colour-vision normal in all six. In 1881 Dr von Forster recorded the result of an exhaustive examination of the colour-perception by several methods in a perfectly albinotic, well-developed girl aged 18 with 6 D. of myopia and acuteness of vision, corrected, one sixth of normal (Fig. 406). Her colour-perception was excellent even for the finer shades. In the case of an albino lady from Cape Town (no pedigree obtainable) tested by Mr Herbert Parker in London, there seemed to be a slight defect for green; but as the patient was but poorly educated, had very bad sight, and was examined only once, the case is not a strong one. In the family shown in Fig. 311 the non-albinotic brother, IV. 16, had well-marked colour-blindness and had changed his occupation in consequence, but the two living albinos themselves were found to have normal colour-vision. In Fig. 46 an incompletely albinotic boy (V. 4) had perfect colour-perception although his father and several other relations (none of whom showed any trace of albinism) were colour-blind. The colour-perception was also examined in sixteen albinos by C. H. Usher, two by Mr Lawford, five by Professor La Gleyze, one by Mr Fisher, one by Professor Koster, and one by Mayerhausen (our Fig. 232). In the 37 cases referred to in this paragraph decided defect was found in Mayerhausen's case only[4].

Albinos very often suffer from strabismus (squint) more often divergent than convergent. But as there is nothing peculiar to albinism either in the etiology or character of the squint the subject need not be pursued. When divergent the strabismus is often due to the extremely short distance at which objects have to be held rendering convergence impossible[5].

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[1] The use of green spectacles for albinism was advised by Van Iperen in 1778: see Bibl. No. 90.

[2] Deschamps, 1893: see Bibl. No. 441.

[3] Wartmann, Bibl. No. 243.

[4] The colour testing was carried out in the case of albinos recorded in our pedigrees, Figs. 10 (seven persons), 25, 57, 96, 97, 98, 131, 306, 391, 68, 69, 109 (three persons), 110, 111, 225, 232, 406, 90, 210, 46, 311, and two or three other single cases not worth recording in detail.

[5] Strabismus was noted in the following 27 albino whites in our pedigrees, among the normals in albinotic families nine cases of strabismus were recorded (see pedigrees, Figs. 6, 7, 10, 226, 303, 306, 391, 459, 466, 478 B, 484, 501, 531, 532, 535, 548, 558, 565, 575, 597, 593, 646). The normals were probably not as carefully examined as the albinos, but of course their number is immensely greater. Among the

Data do not at present exist for deciding whether the eyes of albinos who live to adult years remain as free from destructive disease as other eyes of similar refraction, and especially whether intraocular haemorrhage and detachment of the retina, two of the dreaded complications of the higher grades of myopia, are more likely to happen if such myopic eyes are also albinotic. We only happen to know of two instances of this kind (Fig. 55, III. 2 and Fig. 119, III. 5). An albinotic brother of the latter had also lost one eye from injury and the other subsequently, perhaps from sympathetic inflammation.

Senile cataract has been extracted from albinotic eyes to our knowledge in several cases, with good healing and results, and doubtless in other cases of which no record was kept. The first case of this sort was by Fischer[1]. In recent years cases have been reported by Dor[2] (1885), Sandford[3] (1896), Drake Brockman (Hindoo albino)[4], Nettleship, Usher (two cases; see Figs. 95 and 256 in this memoir), Villard (1904)[5].

Albinos are now and then admitted into Institutions for the Blind; but in some of these instances admission has been sought for educational reasons and because the sight had always been too bad for profitable attendance at any ordinary school, not on account of total blindness from disease. Thus in 1848 Cornaz[6] saw a perfectly albinotic boy aged 10 years in an Institution for the Blind in Berne whose sight does not seem to have been worse than that of many other albinos; he saw pretty well in the dusk, and sufficiently in the day to guide himself; he was soon discharged from the Institution. His father was an albino and was exhibited as a curiosity. We have recently addressed inquiries to about thirty of the Schools and Institutions for the Blind in the United Kingdom and have received information of about fifteen to twenty albinos who have been inmates during several years past or are so now. None of these have been blind; and by no means all appear to have had exceptionally bad sight as albinos; they seem to have been admitted generally speaking because the ordinary or "sighted" schools were thought unsuitable for them.

On the whole it does not appear from the information at present available that the eyes of albinos who live to grow up are more vulnerable age for age than pigmented eyes of similar refraction. But the subject requires, and deserves, further study.

Polynesians and dark races, Figs. 347, 363, 572 (Maori), 585 (North American Indian), 613 (Philippine Islands) provide six cases of strabismus in albinos. Among the negro pedigrees we have Figs. 441 and 574, but this by no means exhausts the number of individual cases in which strabismus has been reported in the negro albino, as a study of our Plates will indicate.

[1] See Bibl. No. 197.

[2] See Bibl. No. 398.

[3] See Bibl. No. 470. On the same occasion Sir H. R. Swanzy also reported an operation on an old man, and Mr Snell on a second.

[4] *Ibid.*

[5] See Bibl. No. 519.

[6] See Bibl. No. 256, p. 300, Obs. II. Jean Brand.

SECTION IV. *The Partially Albinotic Eye.*

By *Incomplete Albinism*[1] we mean lack of pigment in the skin and hair alone or in the eyes alone, the former being common, the latter, in man, so infrequent that we have only one well marked case of it (Fig. 94, II. 3, from Mr Hartridge): *Partial Albinism* covers the cases in which the skin or hair is white in patches, also in animals some piebalds and those with what is called "wall-eye" or in Scotland "ringle-eye," that is lack of pigment in the iris of a species that usually has a dark iris. We now know that even in the "wall-eye" itself the albinism may be partial, the iris in both eyes may be colourless in one part, normally pigmented in another, or all normal in one eye, more or less unpigmented in the other; whilst the examination of the eyes of wall-eyed dogs and horses by Mr Coats (see Chapter IX, *infra*) and wall-eyed horses by one of us (C. H. U.) shows that a similar piebald condition may affect the choroid and that even the retinal epithelium may show abnormal inequalities of pigmentation. Examination of certain mice by the same observers shows that the lack of pigment in their eyes may also be unequally distributed. It is therefore strictly correct to speak of a partial albinism of the eye as occurring by itself in certain of the lower animals. The evidence for partial albinism limited to the eyes in man is less complete; congenital heterochromia, difference in colour of the iris in the two eyes, or in different parts of the iris in the same eye, is met with and corresponds to the "wall-eye" in animals; but we are not aware that this human "wall-eye" has, so far, been found to occur in albinotic stocks or to be associated with patches of white hair or skin, and so good an observer as Wilde writing of human albinism says that "although I have seen the hairs on the brow and the eyelashes perfectly white on one side and dark on the other, I have never heard of one eye being albinotic and the other not[2]." As to the pigment of the choroid and retina in the human eye we have as yet no proof based on anatomical examination that it can, as in the animals above named, be so unequally distributed as to justify the term partial albinism limited to these parts; but as we have said more than once already there are strong clinical grounds for the assumption that this form of partial albinism does occur in man.

Before going further with this subject it must be noted that the correlation between the quantity of pigment in the skin, hair and eyes of normal persons is not very intense[3]. The relationship may change even for the same person before and after adult age; there are many, even racial, exceptions to the general rule that blue or gray irides and light-coloured choroids go with blond skin and fair hair, and hazel or brown irides with dark choroids, brunette skin and dark hair. (1) Everyone is familiar with the gradual darkening of the hair with age that is so common as fair-haired children grow up, and although in many of these the irides remain blue or bluish, close observation might show that in some of them the iris, like the hair, underwent a definite change of colour due to formation of pigment in its stroma[1]. (2) Blue or blue-gray irides are quite frequently met with in persons whose hair has always been quite dark; in many such the skin is very white, but in some it, like the hair, may be swarthy[2]. (3) Much less frequently, and perhaps only in children, brown irides are seen with fair hair, the hair often, perhaps always, getting much darker with age; one of us (C. H. U.) for example saw recently two sibships of seven and four children respectively illustrating this combination[3].

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[1] On pp. 8—9, we have defined "incomplete" and "complete" to refer to the appearance of albinism in some or all the three characters, hair, skin, eyes. "Perfect" and "imperfect" to refer to the degree of lack of pigment. "Partial" to indicate local or particulate albinism; the word "general" is the proper opposite to "partial."

[2] See Bibl. No. 285. It is uncertain whether Wilde was referring to congenital cases or to the instances, rare but well authenticated, in which the eyelashes have become white in the course of a chronic destructive inflammation of the eye (irido-cyclitis).

[3] The actual value of the correlation is given by Pearson, *Biometrika*, Vol. III. p. 461, and Tocher, *Ibid.* Vol. VI. p. 224.

All these varieties, from the fair flaxen hair, bright blue irides and extremely fair choroid, to swarthy and even "black" skin, dark brown irides and intensely pigmented fundus, occur without the defective sight, nystagmus and usually high refractive error found in the eyes that are by general consent classed as albinotic. From end to end of this long series the integrity of the retina is perfect; and as it is known that the pigment epithelium, or some substance associated with it, is of vital importance to sight, we seem to be justified in assuming that the quantity of this pigment in the epithelium of healthy eyes is constant or nearly so whatever may be the complexion of the choroid; but that if the pigment of the epithelium falls below a certain standard sight is defective, although the term albinism is not applied unless the choroidal pigment is lacking also. The key to what we believe to be this very imperfect association between the uveal and dermal pigment on the one hand and that of the retinal epithelium on the other is doubtless to be found in the essentially different nature and uses of the two pigments and the widely different periods of life at which they are developed as already indicated at pp. 269—70. The association seems, however, never to be wanting at the two ends of the scale; we know as yet of no case in which a form of bad sight pointing to deficiency of the retinal pigment co-existed with a highly pigmented choroid, iris and hair; nor of apparently complete lack of colouring matter in choroid, iris and dermal structures with evidence that the retinal epithelium was perfect.

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[1] In children whose hair remains dark from the beginning the iris usually becomes brown in the first months or year of life.

[2] Illustrations will be found in the school surveys for Prussia by Virchow and Switzerland by Kollmann: see Bibl. No. 409 and our p. 160.

[3] One family was as follows: first born, ♀, 21, not seen but said to be "the same as the third"; second, ♂, 12, hair a fair brown, iris very dark brown, choroid so highly pigmented that the vessels are seen as lighter bands; third, ♀, 11, hair very fair flaxen, iris blue with many yellow spots, giving general effect of green; fourth, ♂, 8, hair fair (yellowish), iris dark brown, fundus as in second; fifth, ♂, 6, hair very fair (yellow), iris very dark brown; sixth, ♂, 4, hair fair, iris blue, fundus less pigmented than fourth and second; seventh, ♂, 2, hair fair, iris very dark brown; mother (seen), hair now brown, was fair when young, iris dark brown; father (not seen) has fair hair and blue eyes. The six children were seen all together (August 26, 1908), and Nos. 2, 4, 5 and 7 presented a striking appearance.

In the other family, seen about the same time, of four siblings the first (not seen), ♂, is said to have dark hair and blue eyes; second (not seen), ♂, aged 15, dark eyes, hair formerly fair; third (seen), ♀, aged 10, brown hair, blue iris; fourth (seen), ♀, aged 5, hair fair (yellowish), iris dark brown; mother (seen), hair very dark brown, iris brown; father, no note.

No final classification can be given of the different forms of partial albinism of the human eye from the data at present available, but some of the best marked clinical varieties will now be quoted. Anatomical examinations may in future lead to the list being either extended or condensed.

(1) Cases of incomplete general albinism are fairly common in which when the patient is first seen the iris is blue or gray-blue and the pupil black, but the fundus quite albinotic, vision defective and nystagmus present. In most of these the history is that the pupils were never red[1]. But in a few there is a history of red pupils in early life becoming black later on (Fig. 21, IV. 2, and Fig. 134, III. 3),—a change due either to thickening of the iris or to increased pigmentation of its posterior epithelium[2].

(2) The iris is coloured by pigment and opaque from normal pigmentation of the posterior epithelium, but the fundus albinotic in appearance and the eye imperfect as usual. The colour of such an iris viewed as a whole varies from greenish blue, greenish brown and greenish yellow to shades and tints of brown or even reddish brown according to the quantity, colour and distribution of the pigment. Close inspection, especially with the aid of a magnifying glass, often resolves the pigment into spots, patches or streaks, the seat of election for which is usually over the relatively thick and highly vascular *circulus iridis minor*, just peripheral to the edge of the pupil. Except in cases where the whole iris is uniformly coloured, its periphery, the thinnest part, shows in such cases little or no pigment and is blue. Irides of this type are exceptional in European albinos[3], but very common in the albinos of dark races[4]. The following London case, communicated by the late Mr Ilbert Hancock, is a good one, although the family history was not fully inquired into. Towards the end

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[1] Figs. 46, 81, 90, 111, 145, 229, 243, 323, 394, 447.

[2] There are many degrees of redness of the albinotic pupil, *e.g.* Figs. 43, VI. 4, 60. IV. 11, 130, 226, 227, 306, 409, 488, 492. In such cases the colour varies with the illumination, being black at one time and some shade of red at another. The refraction of the eye and size of the pupil take some share, as well as the characters of the iris (see p. 275).

[3] For examples see Figs. 244, 393, IV. 20, 445, IV. 3, and 446, II. 7.

[4] Analysis of the colour of the iris in 47 of our cases of albinos of dark races shows it to be quite blue (or whitish blue occasionally) in about half (23) and more or less pigmented in 24. In 12 of the 24 pigmented irides the pigment was found chiefly towards the pupillary or central zone of the iris, in the other 12 it was more uniformly distributed. In the same series the pupils are recorded as red of different shades in 12, but they probably were so in a good many others.

In regard to race there is, so far as the small numbers show, a marked difference between the Fijian albinos and those from African, Malayan, Papuan and Indian sources. Amongst 10 Fijian albinos only one is recorded as having a coloured iris, the other nine being blue. In the 37 albinos of the other races 23 had more or less pigmented irides, and only 14 blue.

The 47 cases will be found in Figs. 9, 129, 201, 202, 266, 275, 285 b, 288, 294, 329, 333, 334, 345, 348, 350, 354, 360, 385, 386, 390, 417, 418, 425, 426, 427, 428, 430, 431, 432, 433, 434, 435, 440, 441, 442 444, 483.

of 1904 a very young male infant was brought to Mr Hancock at the East London Hospital for Children with nystagmus and typically albinotic fundus in each eye, but the irides were dark and the hair "very dark, almost black." About a year later (August, 1905) Mr Hancock found that the hair had become extremely fair and the irides a deep greenish brown, but the fundi were still quite albinotic; two or three months later still the hair was rather less fair as if entering on the progressive pigmentation so commonly met with[1]. The child was then lost sight of. The father was very fair, the mother dark.

L. Müller[2] has also recorded albinism of choroid, retina and hair, the irides and skin escaping. The patient was a man aged 20, whose hair was quite white and fundus quite albinotic, and who suffered from nystagmus, photophobia and very defective sight; his irides, however, were brown and his skin moderately pigmented.

(3) The iris itself may be pigmented, but its posterior epithelium entirely colourless and the fundus albinotic. Examined in the ordinary way the iris of such an eye is of some shade of brown, and on close inspection shows brown pigment, but when the fundus is illuminated the iris turns bright red, or more correctly it almost disappears owing to its translucency, except perhaps at its thickest part, the circum-pupillary zone, just as in an ordinary perfect albino. This variety seems to be rare judging from the paucity of known cases. Professor Fuchs has sent us two examples (Fig. 445, IV. 3, and Fig. 446, II. 7) and Fig. 120, IV. 6, is also a good instance.

(4) Perfect albinism of every part of the eye with moderately pigmented hair we have met with only once, in Fig. 94, II. 3, a case communicated by Mr Hartridge.

(5) In the following case, for which we are indebted to Dr Karl Grossmann, of Liverpool, the iris was the only part decidedly albinotic and, like the last case, it is the only one of its kind with which we are acquainted; it corresponds, so far as the clinical appearance of the iris is concerned, with many cases of "wall-eye" in animals. The patient, a man of 49, came to Dr Grossmann about the year 1905, for defective sight in the L. eye due to incomplete cataract; the R. lens was clear; the pupils were eccentric upwards and inwards to an unusual degree[3]; he was astigmatic. The iris in both eyes was white, but the pupillary margin in each showed a thin line of pigment (as in normal eyes), proving that the posterior epithelium at that part contained a fair amount of pigment; this pigment must, however, have been absent or very scanty over the greater part of the iris, for not only was the pupil red in daylight, but a red reflex was seen ophthalmoscopically through portions of the iris;

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[1] In general albinism the hair is stated to have been white *at birth* in almost all cases where anything is known on the subject. (This is recorded in cases to be found in Figs. 56, 58, 82, 85, 89, 119, 186, 193, 383, and may be inferred in many others.) In some few cases of incomplete general albinism, *e.g.* Fig. 139, II. 1, and perhaps in some where the eye alone has remained permanently albinotic, the hair was dark at birth, as it usually is in normal children, but became very fair in a few months, as in Mr Hancock's case.

[2] L. Müller in Deutschmann's *Beiträge z. Augenheilkunde*, Heft VII. p. 88, 1892: "Ueber eine neue Anomalie der Iris (Vitiligo Iridis) nebst Bemerkungen über Naevus pigmentosa." The main subject of the paper is a peculiar spotted condition of iris, not related to albinism.

[3] Slight displacement of the pupils up and in is almost normal.

the fundus blond but not strictly albinotic. (The observations on translucency could be made only on the R. eye.) No photophobia. Hair of head dark shade of blond. No family history of albinism.

(6) We have alluded more than once to albinism of the retina only. There is reason for believing that injurious deficiency of pigment may be restricted to the pigmented epithelium of the retina and possibly even to a part only of the retinal area[1], the iris being blue or gray (never brown as far as recorded cases show) but not translucent, and the choroid light but not usually to such degree as to suggest albinism; the pupils never red. Hair often very fair in childhood, becoming well pigmented later. There is nystagmus, considerable astigmatism, and irremediable defect of sight. No microscopical examination has been made of such eyes, and the diagnosis of purely retinal albinism has been made by indirect evidence and exclusion; the condition is often found in several siblings and appears to be commoner in males than females, whilst in some instances (as in Fig. 295, Mr Jameson Evans's case) typical general albinism has occurred in the same family. Other examples believed to be of the same type are found in Figs. 402, 410, 448 and 449.

The view here taken that the pigment of the retinal, or visual, epithelium is a nearly constant quantity in normal eyes of all complexions cannot be expected at present to meet with more than partial acceptance. The degree of pigmentation of this stratum is, we believe, generally assumed to vary directly as that of the choroid.

But as this pigment is in some way essential to the function of vision, we seem forced to assume that its quantity must be the same,—within narrow limits of variation,—in all normal eyes. The attention of histologists does not appear to have been much directed to the point and until more is known from the examination of specimens we must speak with caution. Possibly it may turn out that of the two pigment elements in the epithelium the pigment rods or so-called crystals and the pigment granules, which according to Raehlmann are of different colours, one may vary with variations in the pigmentation of the choroid and the other be constant, and that deficiency of both sorts is necessary for the defective vision of albinism. Such microscopical examinations as we know of support the position that the amount of epithelial pigment is constant in European eyes; Mr Coats tells us that in human eyes with colourless iris and choroid the pigment epithelium shows, in an average of sections, no sensible difference in amount of colour from that in dark eyes; and Professor Fuchs, to whom we wrote on the subject, replied to the same effect. The point cannot be decided by ophthalmoscopic examination; the presence and uniformity or irregularity of the epithelial layer are of course readily appreciable, but not its relative depth of pigmentation in different eyes. The apparent depth of shade of the epithelium would be expected to vary with the quantity of light reflected by the choroid behind it; and hence the epithelial layer should appear to the ophthalmoscope lighter in an eye with a fair choroid than in a dark eye; but such an appearance does not prove that the quantity of pigment in the retinal epithelium itself is less in the eye with the fair choroid than in the other. Indirect support of this position may be derived from retinitis pigmentosa, a malady in the course of which there is a slow migration of the epithelial pigment from its normal position within the cells to the inner layers of the retina, where it collects in relatively large masses around the blood-vessels. The apparent quantity of this migrated pigment as estimated in ophthalmoscopic examination does not seem to vary in relation to the pigmentation of the choroid, hair or skin of the individual as it might be expected to do if the normal pigment epithelium varied in the same manner. But more extended microscopical work on the pigmentation of normal eyes of different complexions and different races is required. In sections of one or two dark-race eyes it has seemed to me that the epithelial pigment was darker than in Europeans; but these sections were relatively thick and unsatisfactory.

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[1] Nettleship, Bibl. No. 502, p. 110.

This group of cases again raises the question of the relationship of the nystagmus to albinism and of the usually coincident astigmatism to either or both. The latter, the astigmatism, is the chief difficulty and has been referred to already.

The cases are most often recorded under the heading of "Hereditary or Family Nystagmus"; albinism, although sometimes mentioned, has usually been dismissed. The question is whether the nystagmus and irremediable amblyopia can be explained solely by the presence of considerable astigmatism, or must a deficiency of retinal epithelial pigment be added? And if the latter be the truth is the astigmatism a mere coincidence or is it associated with the pigmentary defect? It has been suggested at pp. 280—2 that there is usually association in the ordinary or high degrees of albinism, and if so the same is probably true for the slight cases we are now discussing. Astigmatism is seldom, if ever, accompanied by nystagmus unless there is also irremediable amblyopia, amblyopia that cannot be removed by prolonged use of proper spectacles. There is also no doubt that in the families with hereditary nystagmus and irremediable defect the iris of the affected members is usually blue, or at least gray, and the fundus more or less pale, whilst the normal sighted members of the family with steady eyes generally, or often, have decidedly brown irides. That nystagmus should sometimes be absent in slight ocular albinism is not more surprising than its occasional absence in more pronounced cases, *e.g.* Fig. 130, IV. 12, 13 and 14[1];

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[1] An even more striking example of almost complete albinism of all parts except, as we must assume, of the retinal epithelium is recorded by E. Nettleship, *Roy. Lond. Ophth. Hosp. Reports*, XI. p. 387 (1888). ♂, 28, moustache almost white, hair very light, irides bluish gray and translucent both to daylight and focal illumination; V. $\frac{6}{6}$ partly; no intolerance of daylight and no nystagmus observable in daylight, but ophthalmoscopic examination causes both in a slight degree. Has three sisters and two brothers all of like complexion to himself and none have made any complaint of their sight.

The following additional cases of nystagmus, defective vision and astigmatism in blue-eyed males may be noted here: Hugh ——, aged $7\frac{9}{12}$ in 1896 (P. 38, p. 175); no nystagmus recorded; hair fair flaxen, but was nearly white for a time, V. each eye $\frac{6}{12}$, L. not so well as R. In April, 1900, aged nearly 13, refraction under atropine only H. 0·5 vertical and 1 horizontal, V., with correction, R. $\frac{6}{12}$, L. $\frac{6}{9}$; colour-vision (wools) normal; choroids *very* fair, and yellow spot region rather stippled; "is the defect partial albinism?" Is second born of three; No. 1, ♂, seen, four years older than patient, has 2 D. of M. and

Fig. 211, III. 5, a complete albino of 85; and Fig. 226, III. 14 and IV. 3. Fig. 414 shows three young siblings almost identical as to apparent degree of albinism, but only one of them with nystagmus, viz. the only one with much astigmatism. In Fig. 400 we have the counterpart of this case; four siblings with high astigmatism, three of them albinos with nystagmus, the other, the only one with steady eyes, being normally pigmented. This oscillation is a symptom, as already insisted upon, of imperfection of sight from birth or early infancy; but the degree of visual imperfection required to prevent the development of normal steady binocular fixation is doubtless not the same in all infants. It is not every coal-miner who gets nystagmus, whilst of persons who become blind after infancy some lose the power of fixation and acquire irregular or even truly rhythmical movements more quickly or in a more marked degree than others. Without denying that cases of unexplained amblyopia of, say, from $\frac{6}{12}$ to $\frac{6}{24}$ may occasionally be due to high astigmatism alone and others to deficient epithelial pigment alone, we provisionally take the position that incurably defective sight of the class under consideration usually requires the presence of both imperfections; that the two defects are often associated and the result of a fault in the development of the cornea-scleral tissues and retina of early incidence, slight intensity and brief duration; and that the nystagmus is due more to defective retinal perception than to the astigmatic distortion. But emphasis must again be laid upon the need for microscopical examination of the retinal pigment layer in numerous human eyes of different complexions and from different races, and in infants as well as adults, before the normal limits of its variability and the possible validity of the above hypothesis can be settled. Such examination of the eyes of young children is especially necessary, for a merely temporary deficiency of pigment in the retinal epithelium in early life may, for anything we know, be enough to cause permanent arrest of sight.

That the nystagmus is due more to the albinism than to the astigmatism is probable when we see that defect of sight is on the whole greater the more intense

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V. corrected $\frac{6}{5}$; is typically colour-blind; complexion of hair and eyes not noted. No. 3, ♀, 1½ year younger than No. 2, has good eyes and Em. refraction; colour of hair and eyes not noted.

F. family (P. 36, p. 175), 1896. Only two out of nine siblings seen. Family history not given. The sibship is as follows: One, ♀, aged 22 (1895); blue irides and commencing cataract in each eye; colour of skin and hair not noted. Case seems to have no relation to albinism; two, ♀, brown eyes, good sight; three, ♂, 19 (1895), blue eyes, small quick horizontal nystagmus, under atropine R. simple My. As. 1·5 D., V. $\frac{6}{9}$ partly, L. mixed As. – 1·5 D. spherical with + 2·5 D. cylinder, V. $\frac{6}{9}$ partly, colour-vision quite good (wools); colour of hair not noted; four, ♂, blue eyes and said to have defective sight and more nystagmus than three. Five, ♀, brown eyes, sees well, no spectacles. Six, ♂, blue eyes, wears glasses, believed to have steady eyes. Seven, ♀, aged 10 (1895), blue eyes, but good sight. Eight, ♂, brown eyes, good sight, no glasses. Nine, ♂, aged 4 (1895), blue eyes, but believed to be all right. Information from an aunt, and not complete.

A similar case in a boy of 13 is recorded by E. Nettleship in the same *Reports*, xv. p. 114 (1903), Case I, and we are able to add that this patient, now an officer in the Indian Army, was seen again in 1906, when about 35, by Mr Lawford, who found the V., refraction (H. As.) and nystagmus exactly the same as on my second examination at the age of 17, and noted further: pupils normal to light, hair light brown and had never been extremely fair, choroids fairly pigmented. The irides were blue-gray or gray, colour-vision normal.

the albinism, and that, as already stated, in a few albinos there is no astigmatism (see p. 282 and p. 285 ftn.). On the other hand, in very slight albinism the addition of the refractive imperfection may be required to prevent the acquisition of steady fixation, *i.e.* to cause nystagmus, as in one of the cases given in the footnote on p. 301.

The next question is whether partial albinism can be said to affect a portion only of the eye, *e.g.* a sector of the iris in one eye or both, or the whole iris of one eye that of its fellow eye being pigmented? These conditions, heterochromia iridis[1], have not usually been thought of as related to albinism, although the term "partial albinism of the iris" has sometimes been used by authors[2]. Ordinarily the iris in these congenital cases is perfect in every respect except the colour anomaly, but Francke[3] has recorded a case in which a blue iris presented over a large sharply defined irregular sector marked thinning and faulty structure with absence of pigment in the posterior epithelium. The colour of the iris in the other eye, not stated, was presumably blue also. The condition was thought to have dated from foetal life, but no proof is given. The patient was a woman aged 60.

When the iris of one eye is pigmented all over and that of the other only on a sector or sectors, we are generally dealing with an isolated but congenital anomaly[4], and we have one such iris in association with general albinism in Fig. 142. This condition of the iris may be compared with the congenital whiteness of a tuft of hair or of a patch of skin, which also are occasionally found in association with general albinism in other members of the family (see Figs. 51, 104, 106 and 234) and Mr Flemming's new case (Fig. 543). A localised defect or unequal distribution of pigment at the fundus is occasionally noticed in ophthalmoscopic examination as in Fig. 40, IV. 4; and similar inequalities are sometimes seen where there is no general albinism.

In general it must, however, be added that when either the whole or part of one iris is blue or gray, that of the other being brown, careful examination is required to exclude disease. Chronic inflammation of the iris and ciliary body (irido-cyclitis) is a well-known cause of change in colour of the iris from brown to gray or blue, and when the disease is limited to one eye and accompanied by but slight symptoms the condition may be and in former times was generally mistaken for a congenital peculiarity. In the ten cases of heterochromia iridis published by Sym[5], the light eye had cyclitis or choroiditis in no less than seven.

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[1] Among recent papers on this subject see Anton Lutz, "Ueber einige Fälle verschiedener Färbung der Iris beider Augen," Inaugural Dissertation, Zürich (*Zeitschrift für Augenheilkunde*, Bd. XIX. Berlin), 1908, and "Ueber einige weitere Fälle von Heterochromia iridum," *Deutsch. Med. Wochensch.*, June 10, 1910, p. 1125.

[2] Albinisme partial de l'iris, Dor, Bibl. No. 395 (1885), and Dujardin, Bibl. No. 440 (1890). Dor's case was atrophic thinning of "a segment" of the iris with disappearance of the pigment epithelium, the result of disease, serous iritis.

[3] E. Francke, "Eine eigenthümliche congenitale Anomalie der Iris," *Centralblatt f. Augenheilkunde*, Bd. IX. S. 101—5 (1885).

[4] But cf. Dor's case above mentioned.

[5] Sym, *The Ophthalmic Review*, Vol. VIII. p. 202, London, 1889.

CHAPTER VIII.

ALBINOTIC HAIR (MAN AND LOWER ANIMALS).

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A. *Introductory.* The hair of the albino is a topic of very great interest, and one which has probably not up to the present been studied in as full detail as it deserves, although valuable papers by Frédéric and others exist and will be referred to below. The authors of the present memoir have endeavoured wherever possible to obtain samples of albino hair, and an extensive collection of such hair has been formed in the course of the last six years. The bulk of this material was placed in the hands of Dr F. H. Scott for microscopical examination, but certain additional investigations have been made by Miss E. Y. Thomson and are included in Sections D and E. The results appear to be of very considerable interest and suggestive for further inquiry in a variety of fields.

A very slight macroscopic examination of a large range of albinos' hair in both European and native races shows that the hair of persons with both complete and incomplete ocular albinism is by no means always white in general appearance. It ranges through all shades of cream, yellow, mouse-colour, yellow-red to even brilliant fox-red. Further, in the same individual it may be yellow at one time and white at a second, or yellow on one and snow white on a second part of the scalp[1]. In many cases of these yellow to red albino hairs there appears to be no granular pigmentation at all; air vacuoles may be numerous; but the colouring is wholly due to "diffused" pigment. In other cases there are sparse normal-sized pigment granules; in still others more frequent, but exceedingly diminutive pigment granules. But the matter does not end here: the same absence of granular pigmentation has been found in a considerable number of cases of red hair, in one or two extreme blue-eyed, yellow-haired blonds, and in a few with mouse-colour hair. In such cases there may be no suspicion of either ocular albinism or albinism of the skin. Extending the investigation to animals, a like absence of microscopically visible granular pigment has been found in the coat hair of certain fawn, "lilac," and chestnut animals, which have not hitherto been considered as in any way incomplete albinos, and in view of this it has become increasingly difficult to define what is to be understood by complete albinism of the hair. The snow white hair of the clinically complete albino may be found to contain on microscopic examination a few pigment granules or, perhaps, even a single hair or two may contain quite a number, the remainder of the hair being pigmentless[1]. On the other hand brilliant red or yellow hair may contain not a single pigment granule, and yet its colour lead the merely clinical observer to the denial of the full albinotic character. Such hair may occur in conjunction or not with ocular albinism, and has been noted in stocks, both of men and animals, where cases of complete albinism have been recorded previously or simultaneously[2].

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[1] A striking illustration of this occurs in the hair of Thérèse Rey, V. 65 of our Fig. 640. One sample from the scalp is snow white, but elsewhere it is deeper than sulphur and like the very yellowest raw silk which children obtain from the silkworm.

If, then, we take the total absence of granular pigment to be the test of complete albinism of the hair, we must remember that this, while including a certain number of dark-skinned albinos, whose yellow and reddish hair has hitherto marked them as incomplete albinos, will further include as complete albinos for the hair a number of persons not hitherto suspected of albinism[3]. If on the other hand we assert that complete albinism is marked by the total absence of both granular and diffused pigment, then we might be compelled to treat certain albinos as partial albinos, for a part of their hair may be snow white and a part yellow, and further they may have to be recorded as complete at one period and incomplete at another period of their life. The only practical solution is, we think, to maintain, as Dr Scott suggests, the absence solely of granular pigmentation as the test of albinism of the hair, but in doing this to realise that albinism of the hair ranges through a wide series of degrees, and exists in a number of individuals (among men and the lower animals) not hitherto suspected of complete albinism, or possibly not of albinism at all.

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[1] For the occurrence of single pigmented hairs in the beard or scalp-hair of albinos see our Figs. 41 and 57. A most noteworthy case is that of the Edinburgh deaf-mute albino (Fig. 649), whose snow white hair with no granular pigment contains an isolated deeply pigmented patch: see Plate OO (137) and (138).

[2] There are marked instances in our pedigrees: see for example our Figs. 573 (II. 2, no ocular albinism) and 364 (VIII. 20, no ocular albinism): see also the discussion later of the Rufous Albino and of Albino Dogs, in the stock of which highly coloured coats, the hairs of which have no granular pigment, are found.

[3] Beside the boy, VIII. 20, of Fig. 364, whose hair contains, if any, far fewer granules than that of several individuals treated as complete albinos, a second noteworthy case N. W. was recently observed by K. Pearson in a large Girls' Public School. This child, aged 11, had deep blue eyes, no apparent albinism of the skin, and the palest yellow hair, in which on microscopic examination not a single pigment granule could be found. The hair of VIII. 20, Fig. 364, has been re-examined after an interval of three years; it is very sensibly darker, but no granules were discoverable. Cases 83 and 84 of Table Section B possibly belong to this group.

Cornaz (Bibl. No. 326) refers to a young boy from La Sarraz, Canton Vaud, of brown skin, deep blue irides, and blond approaching white hair, clearer than that of several albinos Cornaz had seen, and which he tells us showed no pigment on microscopic examination. If this means absence of granular pigmentation (observation made in 1849), then Louis-Frédéric-Henri Cugny, Cornaz's boy, must be classed with our cases just referred to. His two brothers, but not their parents, were said to be like him.

Still a further case is that of an extremely blond child, aged 2, with no ocular albinism, blue irides and quite healthy skin; noticed by K. Pearson at Danby in Yorkshire, September 1910 (Table B, No. 115). On examination the hair showed no granular pigmentation at all and the diffused pigment was of the very palest character.

Our general conclusion must be that albinism of the hair is as widely diverse in character as albinism of the eye, and that it is as vague to speak generally of the albinotic or non-albinotic hair as it is to speak of the albinotic or non-albinotic eye. A whole range of pigment variations exist in both characters, and it seems highly probable that the same could be asserted of the albinotic skin if we were able to study in a large number of individual cases the nature of the pigment cells or to record their absence.

SECTION B. *Catalogue of Hair Samples examined*[1].

Continuous Number	Index and Plate No.	Initials, Name or Pedigree Number	Nature[2]	Remarks
1	κ. A_1	Fijian	Normal	See 32 and 33
2	κ. A_2	"	"	
3	κ. C_1	♀, aged 4, English	"	Same person's hair very dark, nearly black at 50
4	κ. C_2	♀, aged 5, A. D., English	"	Samples of fair hair
5	κ. C_3	♀, aged 13, A. B., English	"	
6	κ. C_4	♀, aged 7, E. D., English	"	
7	κ. C_6	♀, aged 4, R. H., English	"	
8	κ. C_7	♂, aged $3\frac{1}{2}$, C. H. S., English	"	
9	κ. C_8	♂, aged $2\frac{3}{4}$, A. M., English	"	
10	κ. C_5	♀, aged $3\frac{1}{2}$, L. K., Russian Jewess	"	
11	κ. B_1	♀, aged 27, L. F., Fig. 447, II. 1, English	Incomplete albino	—
12	κ. B_2	♂, R. G., Fig. 467, III. 10, Norwegian	" "	Sent by Dr V. Magnus
13	κ. B_3	♀, aged 27, J. M., Fig. 393, IV. 20, Scottish	" "	Sent by C. H. Usher
14	κ. B_4	♂, P. K. W.	Premature whitening of hair	—
15	κ. B_5	♂, Fig. 365, III. 10, Norwegian	Albino	Sent by Dr V. Magnus
16	κ. B_6	♂, Fig. 365, III. 13, "	"	" "
17	κ. B_7	♂, Fig. 365, III. 15, "	"	" "
18	κ. B_8	♀, aged 53, E. McM., Fig. 22, III. 4, Scottish	Incomplete albino	Sent by C. H. Usher
19	κ. B_9	♀, aged 32, H. S., Fig. 1, IV. 6, English	'Rufous' albino	Cf. E_{42}, eyes completely albinotic; hair much redder than seen on plate
20	κ. B_{10}	♀, aged 6, British New Guinea: see our pp. 78—79	Incomplete (?) albino	Hair paler yellow than plate
21	κ. B_{11}	♂, B. H., ?Fig. 366, III. 12, Norwegian	Albino	Sent by Dr V. Magnus
22	κ. B_{12}	♂, aged 12, A. M., Fig. 501, V. 16, Scottish	Incomplete albino	—

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[1] This serves also as a description of Plate κ.

[2] Defined by ocular albinism.

Continuous Number	Index and Plate No.	Initials, Name or Pedigree Number	Nature[1]	Remarks
23	κ. B_{13}	♀, aged 14, M. M., Fig. 501, V. 13, Scottish	Normal sister of B_{12}	Hair as light as and formerly lighter than B_{12}
24	κ. F_1	♂, aged 4, A. P., Fig. 364, VIII. 22, English	Extreme blond, not albino	Albinotic stock
25	n.e.	♂, aged 7, A. P., Fig. 364, VIII. 22	Same child	Hair much darker
26	κ. S_2	♂, Fig. 417, III. 2, Woodlark Island	Normal Native	Father of albino child. See Plates V and W, cf. S_3
27	κ. D_1	♂, aged c. 45, Delimilu, Fig. 348, II. 2, New Guinea	Albino	See Plate X (76)
28	κ. D_2	♀, aged 16, Chesiwandivi, Fig. 430, II. 3, Nyassaland	,,	See Plate Y (77)
29	κ. D_3	♂, aged 25, Ng'ombe, Fig. 427, II. 3, Nyassaland	,,	See Plate Y (80)
30	κ. D_4	♀, aged 1, Fig. 431, II. 4, Nyassaland	,,	See Plate Y (79)
31	κ. D_5	♀, Fig. 428, III. 3, Nyassaland	,,	See Plate Z (84)
32	κ. D_6	♀, Loraina, Fig. 485, IV. 2, Fijian	,,	Cf. A_1 and A_2. Sent by Mr K. J. Allardyce
33	κ. D_7	♀, aged 17, Elenoa, Fig. 429, IV. 3, Fijian	,,	Cf. A_1 and A_2. Sent by Mr K. J. Allardyce
34	κ. E_1	♂, aged 44, English, Beard, Dr C.	Complete albino	Same individual, reddish hair without granular pigment
35	κ. E_2	♂, aged 44, Head, Fig. 45, IV. 11	,, ,,	
36	κ. E_3'	♂, J. H., Fig. 366, III. 7, Norwegian	,, ,,	Sent by Dr V. Magnus
36^{bis}	κ. E_3''	♀, K. H., Fig. 366, III. 8, ,,	,, ,,	,, ,,
37	κ. E_4	♂, I. J., Fig. 457, III. 2, ,,	Albino	,, ,,
38	κ. E_5	♀, M. S., Fig. 460, VI. 5, ,,	Incomplete albino	,, ,,
39	κ. E_6	♂, I. S., Fig. 460, VI. 10, ,,	Complete albino	,, ,,
40	κ. E_7	♂, P. S., Fig. 460, VI. 9, ,,	,, ,,	,, ,,
41	κ. E_8	♀, R. G., Fig. 365, III. 6, ,,	,, ,,	,, ,,
42	κ. E_9	♂, A. B., Fig. 472, III. 3, ,,	Albino	,, ,,
43	κ. E_{10}	♀, A. O. S., Fig. 460, IV. 6 ,,	Complete albino	,, ,,
44	κ. E_{11}	♀, aged 2, Fig. 414, V. 10, English	Albino	Eyes not completely albinotic
45	κ. E_{12}	♀, aged 5, Fig. 414, V. 8, ,,	,,	Eyes not completely albinotic
46	κ. E_{13}	♀, aged 6, Fig. 414, V. 7, ,,	,,	Eyes not completely albinotic
47	κ. E_{14}	♀, aged 5 months, ,,	Complete albino	Sent by Mr W. I. Hanesch
48	κ. E_{15}	♀, aged 7, T. M., Fig. 130, IV. 14, Scottish	Incomplete albino	Sent by C. H. Usher
49	κ. E_{16}	♂, aged $2\frac{1}{2}$, J. S., Fig. 413, V. 4, ,,	Albino	Sent by Dr Souter and C. H. Usher
50	κ. E_{17}	♀, aged 16, Fig. 372, III. 1, English	Albino	Sent by Mr N. Bishop Harman
51	κ. E_{18}	♀, Fig. 456, III. 2, Norwegian	Complete albino	Sent by Dr V. Magnus
52	κ. E_{19}	♀, Fig. 456, III. 3, ,,	,, ,,	,, ,,
53	κ. E_{20}	♂, Fig. 456, III. 4, ,,	,, ,,	,, ,,
54	κ. E_{21}	♂, Fig. 456, III. 8, ,,	,, ,,	,, ,,
55	κ. E_{22}	♂, aged 5, Fig. 86, III. 9, English	,, ,,	Sent by Mr Herbert Fisher
56	κ. E_{23}	♂, aged 13, Fig. 86, III. 7, ,,	,, ,,	Sent by Mr Herbert Fisher
57	κ. E_{24}	♀, aged 9, Fig. 86, III. 8, ,,	,, ,,	Sent by Mr Herbert Fisher
58	κ. E_{25}	♂, aged 25, Fig. 87, IV. 1, ,,	Incomplete albino	Sent by Mr Herbert Fisher

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[1] Defined by ocular albinism.

Continuous Number	Index and Plate No.	Initials, Name or Pedigree Number	Nature[1]	Remarks
59	κ. E_{26}	♀, sister born since Fig. 87, engraved, with like type of albinism	Incomplete albino	—
60	κ. E_{27}	♂, aged 43, Fig. 43, VI. 4, English	Complete albino	Sent by Sir H. R. Swanzy and Mr H. Fisher
61	κ. E_{28}	♂, aged 3, Fig. 411, IV. 3, English	,, ,,	Sent by Mr Lang
62	κ. E_{30}	♀, E. W., Fig. 495, V. 7, Norwegian	,, ,,	Sent by Dr V. Magnus
63	κ. E_{31}	♂, T. W., Fig. 495, V. 10, ,,	,, ,,	,, ,,
64	κ. E_{32}	♀, I. W., Fig. 495, V. 6, ,,	,, ,,	,, ,,
65	κ. N_1	Aged, English	Senile gray hair	Sent by E. Nettleship
66	κ. N_2	Dr A., Russian	Non-senile, *i.e.* congenital gray hair	Microscopically $= E_1$ or E_2, sent by Dr Scott
67	κ. S_1	♂, aged c. 28, Fig. 541, II. 4, Gawa Island Native	Complete albino	Sent by Mr John Taafe, see Plate GG (101). Cf. S_2
68	κ. S_3	♀, aged 6, Fig. 417, IV. 1, Woodlark Island	,, ,,	See Plates V & W. Cf. S_2. Sent by Mr John Taafe
69	κ. S_5	♂, aged c. 22, Jappé, Fig. 441, III. 2, Kaffir	Xanthous	Actual hair redder than Plate κ, sent by Dr G. A. Turner
70	κ. S_6	♂, H. T., Fig. 576, IV. 1, Gilbert Islander	"Albino"	Sent by Mr G. M. Murdoch, see Plate GG (104)
71	n.e.[2] S_7	♂, aged 16, Fig. 597, IV. 1, Syrian	Normal	Jet black hair, sent by Dr Manasseh
72	n.e. S_8	♂, aged 8, Fig. 597, IV. 6, ,,	,,	Jet black hair, sent by Dr Manasseh
73	n.e. S_9	♀, aged 13, Fig. 597, IV. 3, ,,	Incomplete albino	Brilliant light golden hair like No. 67, but not matchable on Plate κ, see Plate NN (129). Sent by Dr Manasseh
74	n.e. S_{10}	♀, aged 25, N., Fig. 597, IV. 31, Syrian	Complete albino	As white as E_{32}. Sent by Dr Manasseh
75	n.e. S_{11}	♂, aged, E. A., Fig. 597, IV. 23, Syrian	Incomplete albino	$= B_{12}$ or B_{13}. Sent by Dr Manasseh, see Plate NN (131)
76	n.e. E_{40}	♀, aged 1¼, Fig. 568, IV. 8, Russian Jewess	Complete albino	Pale gold, sent by Dr Bulloch
77	n.e. E_{41}	♂, R. A., Fig. 610, III. 3	,, ,,	Hair of purest dull white, lacking silky character, sent by C. H. Usher
78	n.e. E_{42}	♀, aged c. 8, C. W., Fig. 606, IV. 3	'Rufous' albino	Chestnut red, sent by C. H. Usher
79	n.e. E_{43}	♀, aged 35, Fig. 551, III. 6	Leucoderma, normal black hair	Sent by K. Pearson
80	n.e. E_{44}	♀, L., same as 79	Leucoderma, white hair	,, ,,
81	n.e. κ_1	♀, aged 74, Thérèse Rey, Fig. 640, V. 65, Swiss	Complete albino	White hair } Sent by C.H.Usher
82	n.e. κ_2	♀, same as 81	,, ,,	Yellow hair }
83	n.e. α	♂, L. T., Fig. 640, VII. 77, Swiss	Very fair	} Blonds descended from albinotic stock
84	n.e. β	♀, Fig. 640, VII. 45, Swiss	Extreme blond	}
85	n.e. γ_1	♂, aged 11, Fig. 649, III. 5, Scottish	Albino (white hair)	} Deaf mute: see Plate OO (137) and (138), sent by C. H. Usher
86	n.e. γ_2	♂, same as 85	Albino (black tuft)	}

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[1] Defined by ocular albinism.

[2] n.e. = not engraved.

Continuous Number	Index and Plate No.	Initials, Name or Pedigree Number	Nature[1]	Remarks
87	n.e. η	♂, W. C., Fig. 642, III. 4, Scottish	Albino	Sent by C. H. Usher
88	n.e. ζ_1	♂, boy, Fig. 648, II. 2, Nyassaland	,, (scalp hair)	Sent by Dr B. H. Robertson, see Plate PP (142)
89	n.e. ζ_2	Same as 88	,, (pubic hair)	
90	n.e. λ	♀, aged 11, N. W., English	Extreme blond	Complete want of granular pigment in hair
91	n.e. μ	♀, adult, English	Pale red blond	Minute fine granules but few in number
92	n.e. A_3	♀, adult, Sanai, Fig. 345, Fijian	Incomplete albino	Sent by C. H. Usher
93	n.e. D_8	♀, aged 17, Nigeria (Hausa), see our p. 135	,, ,,	Dr G. Pollard (per E. Treacher Collins, 31/8/08)
94	n.e. F_3	European human foetus	Normal	Used by Dr Scott
95	n.e. θ_2	♂, Nkomo, Nyassaland, see p. 166	Albino	See Plate VV (159), sent by Dr Davey
96	n.e. θ_3 (i)	♀, old woman, see p. 166, Nyassaland	Normal hair	See Plate VV (159), sent by Dr Davey
97	n.e. θ_3 (ii)	,, ,, ,,	? Senile white hair	See Plate VV (159), sent by Dr Davey
98	n.e. θ_1 (i)	♂, Fig. 632 bis, p. 250, Nyassaland	Piebald, normal hair	See p. 249, sent by Dr Davey
99	n.e. θ_1 (ii)	,, ,, ,,	Piebald, albinotic hair	See p. 249, sent by Dr Davey
100	n.e. 44^{bis}	♀, Fig. 414, V. 10, Scottish	Eyes incompletely albinotic in various degrees	Samples taken two years later; hair slightly darker: see p. 312
101	n.e. 45^{bis}	♀, Fig. 414, V. 8, ,,		
102	n.e. 46^{bis}	♀, Fig. 414, V. 7, ,,		
103	n.e.: *E.P.F.*$_1$	♂, aged 18, Njeche, Fig. *E.P.F.*, Rhodesian	Albino	Scalp hair Sent by Dr Alexander Brown, see p. 316
104	n.e.: *E.P.F.*$_2$	,, ,, ,, ,,	,,	Pubic hair
105	n.e.: *E.P.F.*$_3$	,, ,, ,, ,,	,,	Axillary hair
106	n.e.: *E.P.F.*$_4$	♀, aged 10, Nkondi, Fig. *E.P.F.*, ,,	,,	Scalp hair
107	n.e.: *E.P.F.*$_5$	♂, aged 8, Chisasula, Fig. *E.P.F.*, ,,	,,	,,
108	n.e.: *E.P.F.*$_6$	♀, aged c. 40, Nengosa, Fig. *E.P.F.*, ,,	Normal, mother of albinos (103, 106, 107)	,,
109	n.e.: *E.P.F.*$_7$	,, ,, ,, ,,	Normal, mother of albinos (103, 106, 107)	Pubic hair
110	n.e.: *E.P.F.*$_8$	,, ,, ,, ,,	Normal, mother of albinos (103, 106, 107)	Axillary hair
111	n.e.: *E.P.F.*$_9$	♂, aged 55, Chiwlelde, Fig. *E.P.F.*, ,,	Normal, father of albinos (103, 106, 107)	Scalp hair
112	n.e.: *E.P.F.*$_{10}$	,, ,, ,, ,,	Normal, father of albinos (103, 106, 107)	Pubic hair
113	n.e.: *E.P.F.*$_{11}$	,, ,, ,, ,,	Normal, father of albinos (103, 106, 107)	Axillary hair
114	n.e. Sp. Ser. II.	♂, aged 3, Kalcka, Rhodesian	Half-caste (white × native)	Sent by Dr Alex. Brown, densely packed with granules, black-brown diffused pigment
115	n.e. Sp. Ser. III.	♂, aged 2, E., from Danby, English	Extreme blond	No granules whatever and very very pale diffused pigment

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[1] Defined by ocular albinism.

Continuous Number	Index and Plate No.	Initials, Name or Pedigree Number	Nature[1]	Remarks
116	n.e.: $E.P.B._3$	♂, aged $2\frac{1}{2}$, Fig. *E.P.B.* II. 4, English	Complete albino child	Family with one albinotic son, sent by Dr McMaster Glen. Albino's hair has grown less coloured
116$^{\text{bis}}$	n.e.: $E.P.B._3'$	♂, aged 4, „ II. 4, English	Complete albino child	
117	n.e.: $E.P.B._5$	♀, Fig. *E.P.B.* I. 3, English	Normal mother to albino (116)	
118	n.e.: $E.P.B._4$	♀, „ II. 1, „	Normal sister to albino (116)	
119	n.e.: $E.P.B._6$	♂, „ I. 2, „	Normal father to albino (116)	
120	n.e.: $E.P.B._7$	♀, „ II. 2, „	Normal sister to albino (116)	
121	n.e.: $E.P.B._1$	♀, „ II. 3, „	Normal half sister to albino (116)	
122	n.e.: $E.P.B._2$	♀, „ II. 5, „	Normal sister to albino (116)	
123	n.e.: *E.P.A.*	♀, Fig. *E.P.A.*, Scottish	Complete albino	Sent by C. H. Usher
124	θ. III. 7	♂, Fig. 535, III. 7, Scottish	Normal father and grandfather of albinos	Three generations of hair samples in albinotic stock sent by C. H. Usher
125	θ. III. 20	♀, „ III. 20, „	Normal mother and grandmother of albinos	
126	θ. IV. 11	♀, „ IV. 11, „	Sister and aunt of albinos	
127	θ. IV. 12	♂, „ IV. 12, „	Brother and uncle of albinos	
128	θ. IV. 13	♂, „ IV. 13, „	Incomplete albino	
129	θ. IV. 14	♂, „ IV. 14, „	Brother and uncle of albinos	
130	θ. IV. 15	♂, „ IV. 15, „	Brother and uncle of albinos	
131	θ. IV. 16	♀, „ IV. 16, „	Mother and sister of albinos	
132	θ. IV. 17	♂, „ IV. 17, „	Brother and uncle of albinos	
133	θ. IV. 18^1	♂, „ IV. 18, „	Incomplete albino	
134	θ. IV. 18^2	♂, „ IV. 18, „	„ „	
135	θ. IV. 19	♂, „ IV. 19, „	Brother and uncle of albinos	
136	θ. IV. 20	♀, „ IV. 20, „	Incomplete albino	
137	θ. IV. 21	♀, „ IV. 21, „	Sister and aunt of albinos	
138	θ. IV. 22	♀, „ IV. 22, „	Incomplete albino	
139	θ. V. 8	♂, „ V. 8, „	Incomplete? albino	
140	θ. V. 9	♀, „ V. 9, „	Normal sister and niece of albinos	
141	θ. V. 10	♂, „ V. 10, „	Complete albino	
142	n.e. N. 100	♀, aged 8, A. H., Fig. 646, V. 9	„ „	Macroscopic yellowish tinge, Dr Souter
143	n.e. N. 101	♀, aged 15, M. H., Fig. 646, V. 6	Normal sister	Macroscopic dark brown, Dr Souter

In the index column of the above table the letters κ or θ standing first signify that the hair has been reproduced on Plates κ or θ; the letters n.e. standing first signify that the hair has not been engraved or reproduced. The letters following κ, θ or n. e. signify in the first two cases the specimen number on the Plate κ, in the third case the docket number of the preserved hair specimens.

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[1] Defined by ocular albinism.

A very great deal of energy and time has been spent over the lithographed Plate κ. Its relative success and partial failure can only be appreciated by those who compare it directly with the original hairs. It fails in some of the rather brighter yellow and red-yellow tints, but it succeeds in its main purposes, namely to indicate: (i) the wide range of yellow whites in albinotic hair; (ii) the fact that some of the paler whites, which belong to albinos clinically described as complete, have more or less granular pigment in the hair; and (iii) that albinos, who have been classed as incomplete clinically on account of markedly coloured hair, may be really, as far as that hair is concerned, without granular pigment.

As illustration of (iii), we may take the girl C. W., No. 78 of the Table; the hair has no appearance of albinism at all, it is red and not very brilliant red. Give B_9 of Plate κ a red instead of a brown tinge and we have a measure of its intensity. Yet the albinism of the eyes justified a microscopic examination and Dr Scott reports the hair as having no granular pigment. Or, again, take the Syrian hair, No. 73; this girl has hair as deep, although more golden than S_1 of Plate κ. Dr Scott reports a few air vacuoles but no granular pigment[1]. No. 24, F_1 of Plate κ, after three years has hair more like B_{10}, Plate κ, macroscopically, yet here there is no granular pigment in either stage.

Again, take No. 77. This hair is macroscopically a pure dull white, and the man would undoubtedly, as far as the hair is concerned, be clinically described as a complete albino. Some of the hairs were white with numerous vacuoles and no granular pigment whatever; other hairs showed microscopically a faint colour, numerous vacuoles and some granular pigment. Thus, even with microscopic examination, the classification of the individual as albino or not might depend on the individual hair selected. This is again exactly the case of the New Guinea albino child from Kerapunu, certain hairs of which have no granular pigment, while in others it exists: see No. 20. Again, Mr Stanford Morton's case H. S. (Fig. 1, IV. 6) is one in which the eyes are fully albinotic; the hair is, however, "bright yellowish red." This might be like that of C. W., No. 78, which is completely wanting in granular pigment, but Dr Scott reports some granular pigment in H. S.'s hair.

Many of the very blond or extreme blond hairs dealt with are macroscopically far lighter than the albino hairs, but Dr Scott points out that they have usually some granular pigment (see Plate β, Fig. 6). On the other hand, pigment granules may be wanting in fairly dark or red hair, and exist in apparently white hair. Thus mere judgment of colour without microscopic examination, and this of a considerable range of hairs, will fail to determine whether albinism of the hair is or is not complete. This is especially true of the albinos of the dark races, and we feel fairly sure that a number of such albinos have been recorded as incomplete owing to the apparent presence of some sort of pigment in the hair. How far this "diffused" pigment is related to any incomplete ocular albinism is hardly yet known. It is certain that it can exist with absolutely normal eyes (Nos. 24—25, 66, 90) and again with completely albinotic eyes (Nos. 78, 34—5, 81). An examination of the Table in Section D seems to indicate that the great bulk of the albinos of dark-skinned races fall into the class of complete albinos of the hair, if we define that by absence of granular pigmentation. It is among the albinos of the light-skinned races that we find cases of both complete and incomplete ocular albinism associated with some granular pigmentation of the hair. Of course it is not, as we have already indicated, possible to assert the complete albinism of the eye without *post-mortem* microscopic examination, but in several of these cases the albinism of the eye has been returned as complete by competent judges. Again, the complete albinism of the hair is by no means a sure test that clinically the eye will be returned as completely albinotic. This appears to be especially the case with regard to dark race albinos; it may be that when the eye of the dark race albino has been more fully studied—at present ophthalmoscopic examinations have been relatively few and dissections practically none—we shall discover that the apparent absence of the red pupil is not invariably a mark of incomplete albinism[1]; but until that time we must conclude that it is not the coloured hair of the dark race albino which is the essential feature in the incompleteness of his albinism. Red or yellow hair is no evidence at all of the presence of granular pigment, and it is the eye which must be really our guide in deciding how far the albinism is actually complete or not. A sample of hair can easily be procured and tested, but the eye must remain, even if the ophthalmoscope be available, a matter of judgment and, owing to the wide range of grades of ocular albinism, largely a matter of personal equation. All we can say is that with such judgment as we have been able to press into our present task, there appears to be neither in light-skinned nor in dark-skinned albinos any fixed association between complete albinism of the hair and complete albinism of the eye, and it is impossible to judge from the one of the grade of the other.

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[1] Her two brothers Nos. 71 and 72 show black hair as dark as S_2 of Plate κ with numerous black granules.

No better illustration of this can be found than the three sisters of our Fig. 414, V. 7, 8 and 10, whose photographs are given on Plate O (44). They represent different intensities of ocular albinism. Their hairs (Plate κ, E_{11}, E_{12} and E_{13}) are by no means as light as some blonds, yet these hairs are without granular pigmentation[2]—a condition very exceptional in blonds. Yet individuals with eyes as albinotic or more so, *e.g.* Nos. 13, 19 or 77, may show sensible pigment granules and, as in the case of the former two (Plate κ, B_3 and B_9), markedly more visible pigmentation.

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[1] See especially our remarks p. 77.

[2] They have been again examined (August, 1910, by Miss E. Y. Thomson) after an interval of more than two years and have sensibly darkened; we find that: M. A. (No. 100, second sample of Fig. 414, V. 10) has still no granules, there are vacuoles; under low power, not even diffused pigment was visible. V. A. (No. 101, second sample of Fig. 414, V. 8) has still no granules, some vacuoles; under low power no visible diffused pigment. A. A. (No. 102, second sample of Fig. 414, V. 7) differed from the others, there was under low power diffused pigment quite deep in places. With high power there was great doubt as to whether true granules existed. Mr O'Donoghue who examined the hair after Miss E. Y. Thomson, came to the conclusion that some few granules might possibly be present with many vacuoles. The latter differed from ordinary vacuoles, and in both shape and size varied immensely. The hair was very abnormal and gave the impression of breaking down tissue.

Analysis of the Hair Samples of Albinotic Stocks.

The large degree to which ocular albinism is independent of the macroscopic *appearance* of pigment in the hair is rendered very sensible by the Colour Plate θ, which represents the hair of three generations of the albinotic stock of Fig. 535[1]. In this pedigree V. 8, 9 and 10 are the three offspring of the woman IV. 16 and the man IV. 29; the mother's parents are III. 7 and 20; she has 11 brothers and sisters, of whom C. H. Usher and Dr MacHardy, who examined them, report IV. 13, 18, 20 and 22 incomplete albinos. The child V. 10 is a complete albino. In the accompanying Table, the macroscopic order of hair colour is given, the result of the microscopic examination of the hair and the report on the eyes.

Individual	Macroscopic Order of Hair	Microscopic Report on Hair		Ocular Condition
		Granules	Diffused Pigment	
Maternal grandfather, III. 7	No. 9			
	(i) dark hairs	Plenty (δ)	Yellow brown	Iris blue, brown spots, normal
	(ii) light hairs[2]	None	None	
Maternal grandmother, III. 20	No. 10	Plenty (δ)	Light brown	Iris blue, brown spots, normal
Mother IV. 16	No. 14, aged 29	Decided number (γ)	Bright yellow	Iris blue, normal
♀ IV. 11	No. 15, aged 40	Very plentiful (ε)	Yellow brown	Iris blue, normal
♂ IV. 12	No. 3, d. aged 1	Few and very small (β)	Very pale bright	,, ,,
♂ IV. 13	No. 7, aged 36	Decided number (γ), but some hairs very few	Pale	,, nystagmus
♂ IV. 14	No. 16, age ?	Plenty (δ)	Yellow brown	,, normal
♂ IV. 15	No. 17, age ?	,,	Light brown	,, ,,
♂ IV. 17	No. 18, age ?	,,	Brown yellow	,, ,,
♂ IV. 18	No. 5 (i) aged 7	None	Bright yellow	Blue iris, rotatory nystagmus, no photophobia, fundus albinotic
	No. 8 (ii) aged 24	Decided number (γ)	Light brown	
♂ IV. 19	No. 11, age ?	Plenty (δ)	Very pale	Iris blue, normal
♀ IV. 20	No. 6, aged 20	Decided number (γ)	,,	,, nystagmus
♀ IV. 21	No. 13, age ?	Very plentiful (ε)	Yellow brown	,, normal
♀ IV. 22	No. 2, aged 10	None	Scarcely any	Blue iris, no nystagmus, fundus normal
♂ V. 10	No. 1, aged $1\frac{4}{12}$	None, a few vacuoles	None	Iris pale blue, red pupils, nystagmus, photophobia
♂ V. 8	No. 4, age ?	None	Slight green yellow	Iris blue, normal
♀ V. 9	No. 12, age ?	Plenty (δ)	Bright yellow	,, ,,

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[1] The hair colours given in the account of the pedigree were taken by rapid observation before the samples were collected. It is difficult to find any reddish tinge in the hair sample of IV. 14.

[2] Probably due to senile greyness. Originally the hair was very fair.

It will be noted at once that of the members of this family with a γ grade of granulation, *i.e.* hair in which granules were decidedly existent but are not plentiful (δ), IV. 13, IV. 18, IV. 20 and IV. 22 are incomplete albinos; IV. 12 with a lesser grade (β) died as an infant and the normality of the eyes cannot be considered absolutely definite. IV. 16, also γ, if ocularly normal herself, has produced albinotic children. One of her ocularly normal children, V. 8, is, however, as far as the hair is concerned, completely without granules. If we take the macroscopic order of appearance of intensity of colour in hair, the first eight in lightness include all those with no pigment granules, the one case of β and three out of the four cases of γ. In the remaining ten cases the granules are all very plentiful or plentiful (ϵ or δ), except the mother IV. 16. The differences therefore between the macroscopic and microscopic hair orders concern IV. 12, and the mother IV. 16, whose hair is relatively dark but has not much granulation. The ocular albinism follows less closely the albinism of the hair. One child, V. 8, with completely albinotic hair, has normal eyes, and one incomplete albino with an albinotic fundus and nystagmus has changed in seventeen years from a complete state of albinism of the hair to the grade of granulation γ. He has now macroscopically a slightly darker shade of hair than IV. 13, who is ocularly less albinotic. The diffused pigment in the first eight of the macroscopic order is either wholly wanting, pale or yellow, the one exception being the light brown of the latter stage of IV. 18. In the ten darker macroscopic hairs we have, with three exceptions, a tinge of brown in all the diffused pigments; these exceptions are the mother of the albino with bright yellow, her second child, V. 9, with the same, and her brother, IV. 19, with a very pale diffused pigment in a hair with plenty of granules. The following summary may help the reader to grasp the family distribution of pigment:

Macroscopic Order of Hair	1	2	3	4	5	6	7	8
Individual	V. 10	IV. 22	IV. 12	V. 8	IV. 18^1	IV. 20	IV. 13	IV. 18^2
Ocular Albinism	a.	$\frac{1}{2}$ a.	n.	n.	$\frac{1}{2}$ a.	$\frac{1}{2}$ a.	$\frac{1}{2}$ a.	$\frac{1}{2}$ a.
Granulation	0	0	β	0	0	γ	γ	γ
Diffused Pigment	0	?	v. p.	s. g. y.	bri. y.	v. p.	p.	lig. b.

Macroscopic Order of Hair	9	10	11	12	13	14	15	16	17	18
Individual	III. 7	III. 20	IV. 19	V. 9	IV. 21	IV. 16	IV. 11	IV. 14	IV. 15	IV. 17
Ocular Albinism	n.	n.	n.	n.	n.	n.	n.	n.	n.	n.
Granulation	δ	δ	δ	δ	ϵ	γ	ϵ	δ	δ	δ
Diffused Pigment	y. b.	lig. b.	v. p.	bri. y.	y. b.	bri. y.	y. b.	y. b.	lig. b.	b. y.

A table like this indicates how complex and subtle the phases of albinism in man are, and how difficult it is to classify the members of a stock into unit categories like albinotic and not albinotic.

The samples of hair from another white race (English) albinotic family, Extra Pedigree B, were also microscopically examined. In this case we had the hair of the father, I. 2, the mother, I. 3, the albino himself, II. 4, and of his four sisters, II. 1, 2, 3 and 5. Miss E. Y. Thomson found the following results:

Individual	Hair			Iris
	Macroscopic	Microscopic		
		Granules	Diffused Pigment	
Father, I. 2	Yellowish brown[1]	Plenty of granules (δ)	Pale yellow brown (p. y. b.)	Blue
Mother, I. 3	Dark brown	,, ,, ,,	Light brown (lig. b.)	Brown
Half sister, same mother, II. 1	Light, almost golden brown	,, ,, ,,	Yellow (y.)	,,
Sister, II. 2	Medium brown	,, ,, ,,	,,	Blue
,, II. 3	Tow yellow	Decided number (γ)	Pale brown yellow (p. b. y.)	,,
Albino boy, II. 4, aged 2½	Palest yellow	None, 1 or 2 vacuoles ?	Hardly any	Blue, red pupils
Albino boy, II. 4, aged 4	Albinotic white	None, a few vacuoles	None	
Sister, II. 5	Bright yellow brown	Decided number (γ)	Yellow (y.)	Brown

With the exception of the albinos, all the hairs in this case show plenty of granules and there is no pigment anomaly in the parents or siblings. It thus differs widely from the first[2].

In a third case, which is of some considerable interest, we have been able to examine the hair of father and mother and the three albino offspring from the tribe Alenje, chief Ehipepo, from the North West Rhodesia, some 20 miles north of Broken Hill. The hair samples sent by Dr Alexander Brown, through Dr Low of Aberdeen, are Nos. 103—113, with No. 114 as control, cf. Table B. The results are tabled below and a full description of this family will be found in Fig. *E.P.F.*[3] The noteworthy points are that the father appears to have two types of both scalp and pubic hair, one black and the other light. The former densely packed with granules, the latter without; this differentiation may be due to senile changes. He has further "leprous patches" on him, not further defined as to origin or possible progression. They cannot fail to remind the reader of Dr Jones' "spotted negroes" (see our p. 263) who gave rise to albino offspring. The hair of the mother, to judge by the samples sent, is distinctly *brown*, not black, and her skin is described as "brownish." It may be doubted whether she ought not to be classed as of xanthous type, although possibly not in a very marked degree. All the three children are albinos; the youngest has no granular pigmentation and corresponds very closely with Dr Scott's dark-skinned albinos; but the two elder have some granules in their hair samples, and it is of importance to note that their skins have purple blue patches, which are absent in the youngest. The case is of special interest as confirming the view already expressed that different intensities of albinism may appear in the same sibship (see pp. 262—5, 314), and possibly indicating that close examination of the parents of albinos, especially in the dark-skinned races, may show defect of completely normal pigment conditions.

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[1] Said to have been as light as the albino's when young, now quite sensibly brown.

[2] Still a further case has been kindly provided recently by Dr A. R. Galloway and will be found discussed with microscopic analysis in an Appendix to this Chapter.

[3] This refers to Appendix, Extra Pedigrees Fig. F.

Individual and Table B, Sample No. Extra Pedigrees Fig. F.	Hair			Iris
	Macroscopic	Microscopic		
		Granules	Diffused Pigment	
Father, No. 111	Scalp, two types, one black (i), one white (few) (ii)	(i) Densely packed (ζ). (ii) None	(i) Black brown. (ii) None	Brown
,, No. 112	Pubic, two types, one black brown (i), one lightish brown (ii)	(i) Densely packed (ζ). (ii) Few, with vacuoles (α)	(i) Dark brown. (ii) Very little	
,, No. 113	Axillary, dark brown	Densely packed (ζ)	Brown red	
Mother, No. 108	Scalp, chocolate brown	Very plentiful (ϵ)	Red brown	Brown
,, No. 109	Pubic, red (?) brown	Densely packed (ζ)	,,	
,, No. 110	Axillary, brown	Plenty of granules (δ)	Very pale	
Albino son, No. 103	Scalp, pale red yellow	Some granules, vacuoles (β)	,,	Greyish green
Albino son, No. 104	Pubic, bright red yellow	Very few granules, vacuoles (α)	Scarcely any	
Albino son, No. 105	Axillary, bright red yellow (rather more red than 104)	Some granules, vacuoles (β)	Very pale	
Albino daughter, No. 106	Scalp, yellow with perhaps a touch of red	Some granules (β)	Very pale yellow	Greenish
Albino daughter, No. 107	Scalp, pale yellow	No granules, vacuoles	None sensible	Greenish
Rhodesian half-caste, white × black, No. 114	Scalp, *straight* not woolly black hair	Densely packed (ζ)	Black brown	Brown

The hair of the half-caste Rhodesian is macroscopically blacker than that of any member of this family, and is probably more densely packed with granules than that of the father of the albinos. Its striking feature is its straightness; it is like that of the yellow races, not like the wool of the negro.

Dr Scott's investigation of the hair of the leucodermatous ♀, Fig. 551, III. 6, led, as in similar cases, to no differentiation. The normal hair, No. 79, of Table B could only be described, microscopically examined, as normal black hair; the white hairs, No. 80, resembled normal white hairs in "that instead of finding pigment granules the whole pigment cell seems replaced by a vacuole[1]." The absence of granular pigment in the white hair of the "comb" of piebalds and the presence of darkly packed granules in the dark hair of the rest of the scalp are admirably brought out in Dr Davey's specimens of hair from the Nyassaland piebald family: see Hair Samples

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[1] Letter to K. Pearson, 15 December, 1909.

Nos. 98 and 99[1]. The exactly reversed state of affairs is evidenced in the deaf-mute albino boy, the hair of whose scalp contains no granules, but the black tuft hairs contain closely packed granules: see Hair Samples Nos. 85 and 86. The former case shows that for these piebalds the leucosis was truly of the nature of albinism and not a blondism; the latter case indicates how possible it is for the production of pigment to take place in small local areas in an albino, so that it is difficult to conceive albinism as due to a general constitutional incapacity to carry on a metabolic process.

SECTION C. *On the Distribution of the Pigment in Hair with Special Reference to that of Albinos.*

BY F. H. SCOTT, PH.D., M.B.

(*From the Physiological Laboratories, University College, London, and the University of Minnesota, Minneapolis.*)

The various shades and colours of the hair of different individuals depend chiefly on the difference in the colour of the pigment present in the hair. In normal hair this pigment is usually found in the form of small granules deposited between the long fibrillar cells which form the shaft. Besides the pigment granules the appearance of the hair may be modified by varying amounts of air contained in small vacuoles scattered between the fibrillae or in the medulla. In the year 1907 Frédéric[2] called attention to a peculiarity of certain negro albinos. The hairs of certain of these were devoid of any pigment granules, although the hairs themselves are of a bright yellowish tint. These hairs have no granular pigment, but only a "diffused" pigment. A certain light-coloured negro, described as an albino by Frédéric, was, however, found to have hair containing granular pigment. Also Frédéric describes the hair of a young woman from South Germany as containing only diffused pigment. The absence of pigment in the form of granules from the hair can thus not be considered as altogether an albinotic character, although there may be a tendency for that to occur. At Prof. Pearson's suggestion the collection of albinotic hairs made by the writers of the present monograph has been examined microscopically with special reference to the presence or absence of granular pigment.

Before giving the results of this investigation, the nature of hair pigment may be briefly discussed, as it may offer an explanation of the absence of pigment in certain cases. A great many papers on the nature of hair and other pigments have appeared, and a good summary of these numerous works on pigment from different sources will be found in the paper of v. Furth[3]. The chief problem dealt with has been the origin of the pigment. Here the discussion has been principally as to whether the pigment is derived from the haemoglobin of the blood. The fact that certain of the earlier analyses of pigment showed the presence of iron in the ash led many to believe in the haematogenous origin of pigment. It may, however, be taken as definitely proved by the work of many, especially that of Spiegler[1], that hair pigment, choroid pigment or the pigment of melanotic tumours does not contain iron. This alone would not exclude the blood as a source of pigment, as many pigments, *e.g.* bile pigments, are known to be derived from haemoglobin and yet are iron free. However, any origin from haemoglobin has probably been definitely disproved by Spiegler's work. He could not find any bodies resembling haemopyrol among the decomposition products of pigment. It is difficult to believe that if pigment were derived from haemoglobin this would be so transformed as not to yield pyrol derivatives. If we exclude haemoglobin as the source of pigment, we must look for another source, and here the production of melanins by oxidising agents and ferments must be mentioned as the probable source of pigment. The work of v. Furth and Jerusalem[2] and of Spiegler[3] shows that artificially melanins may be prepared which resemble naturally occurring pigments. This is done by the action of certain oxidising ferments on various aromatic bodies. Such artificial melanins yield degradation products resembling those derived from natural pigments. Such an origin would explain the change in colour which occurs when hair is removed from the body. Being removed from its natural environment processes of oxidation may go on which are normally more or less inhibited. In connection with the chemistry of pigment it is interesting to note that Spiegler obtained from white hair (horse and sheep) a similar substance to that obtained from black hair. The two substances gave similar degradation products, and the white substance would darken and resemble the black pigment with suitable treatment. Spiegler believes this is a true white pigment, and that the colour of white hair is due to the presence of this pigment and not merely to the absence of pigment combined with the presence of air vacuoles. As Spiegler points out the colour of the ground substance of hair is horn coloured. This is the colour seen in many albinotic hairs and is especially well marked in the case of the albinos of dark-skinned races.

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[1] We have since received the hair of a second Nyassaland Piebald, we think IV. 4 (or ? IV. 5) of Fig. 632 bis, p. 250. He is aged 19 to 20, and is now called Isaac Nyrenda. There are three varieties of wool: (i) very dark, having very dark diffused pigment and densely packed with granules; (ii) brown, having brown diffused pigment, granules very plentiful; (iii) yellow, no diffused pigment and no granules at all. Cf. the Pekinese Spaniel's hair, p. 344.

[2] See Bibl. No. 553.

[3] See Bibl. No. 524.

Beyond Frédéric's paper already mentioned[4] very little has been published on the microscopic appearance or other peculiarities of albinotic hair. Sachs[1] in 1812 stated that albinotic hair is softer and thinner than normal hair. He also states it contains less iron than normal hair. As his results were obtained from only two cases they are probably questionable, especially since pigment is now known to be iron free. Cornaz[2] describes a difference between albinotic hairs and the white hair of old age, in that albinotic hairs have the medullary substance transversely striated and unpigmented. The white hair of old age is due according to Cornaz to changes in the cortex of the hair, while the medulla contains finely divided darkish particles distributed uniformly. This difference was not observed in the hairs I have examined.

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[1] E. Spiegler, "Ueber das Haarpigment," *Beiträge zur chemischen Physiologie u. Pathologie*, Bd. IV. S. 40, 1904.

[2] "Zur Kenntniss der melanotischen Pigmente und der fermentativen Melaninbildung," *Beiträge zur chemischen Physiologie u. Pathologie*, Bd. x. S. 131, 1907.

[3] "Ueber das Haarpigment nebst Versuchen über das choroidiale Pigment," *Beiträge zur chemischen Physiologie u. Pathologie*, Bd. x. S. 253, 1907.

[4] [Frédéric has more recently investigated samples of the hair of two New Guinea albinos (*Zeitschrift für Morphologie u. Anthropologie*, Bd. XII. S. 369, 1909). The first of these, from an albinotic man from Hula, Quarinama by name (? = Finsch's Kwarinam and our native informer's Warinama: see our p. 79), consisted of light and dark gold coloured hairs; the light had few and in certain cases no pigment granules, the colour being the result of diffused pigmentation; the darker had the smallest gold brown pigment granules, frequently arranged in short rows. The second sample was from Kilapelama (see our Fig. 349 and our p. 79), the albinotic boy. Here the hair is lighter than the former, with a red gold tinge. The hair was a mixture of gold yellow and more light gray yellow hairs; the former had only

The hairs placed at my disposal consisted of 49 samples of albinotic hair. Of these 9 were the hairs of albinos of dark-skinned races and 40 the hair of white-skinned races. As a comparison the hair of many normal individuals has been examined. In dealing with this question it may be well to separate the albinos of the dark-skinned races from those of the white races. We will first describe the hairs of the albinos of the dark-skinned races, as these present the characters described by Frédéric in a marked degree.

The hairs to be examined were mounted in glycerine jelly. This proved better than balsam, since the slower penetration allowed a better investigation as to the amount of air present. If any doubt as to the presence of pigment granules existed, sections were cut of such hairs.

Thirteen examples of hair from dark-coloured races were examined. These include samples from many parts of the globe and may be classified as follows:

		Table (Section B).
1.	Native Fijian, normal individuals. Four samples, hair jet black	Nos. 1 and 2.
2.	Sanai, a Papuan, ♀. Hair brownish. See Fig. 345	No. 92.
3.	Delimilu, a Papuan albino. See Fig. 348 ...	No. 27.
4.	Nyassaland albinos. Four samples, Nos. 3, 4, 5, 6	Nos. 28, 29, 30, 31.
5.	Loraina of Vitogo, a female Fijian albino. See Fig. 485	No. 32.
6.	Elenoa of Noikoro, a female albino. See Fig. 429	No. 33.
7.	A Nigerian albino, aged 17, probably Hausa. Sent by Dr G. Pollard	No. 93.

The first group in the list (Native Fijians) are normal hairs and may be taken as the type with which to compare the remaining groups. All the other samples are

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diffused pigment, in the gray yellow were a few granules. These results are of much interest. Dr Scott had already reported the discovery of two types of hair in the girl from Kerapunu (No. 20 of our Table; see our pp. 78 and 79). They exist macroscopically and also microscopically (Miss E. Y. Thomson) in the hair of Hiram Teeko, the Gilbert Island albino (No. 70 of our Table), and quite recently the macroscopic dull white hair of R. A. (No. 77 of our Table), a Scottish complete albino, has been discovered by Dr Scott to be a mixture of two kinds of hair; some hair white with numerous vacuoles and no granular pigment; other hairs faint colour, numerous vacuoles and granular pigment. K. P.]

[1] See Bibl. No. 151.

[2] See Bibl. No. 256, p. 337.

from true albinos, except No. 2, which is the hair of a light-coloured Papuan who is not a complete albino. Plate β, Fig. 1, represents the appearance of one of the native Fijians. It is seen that the pigment is distributed in the form of fine granules between the fibrillar cells which form the shaft. The fibrillar cells themselves are of a pale yellowish tint. If we compare the hair of the dark-race albino with this a marked difference is seen (Plate β, Figs. 2 and 3). Fig. 2 is from the Papuan albino No. 27. No pigment granules are visible, although the hair is of a horny yellowish tint. This colour is diffuse and is entirely due to a colouration of the ground substance of the cells. The ground substance of hair consists chiefly of keratin, and these albino hairs have more or less the appearance of horn. This absence of pigment granules is the character described by Frédéric for his albinos, and all the hairs of the dark-race albinos examined by me exhibit this peculiarity. The naked-eye appearance of these hairs varies from the colour represented in Fig. 2 to a very light pale yellow such as is seen in Fig. 3. Here not only are there no pigment granules but the ground substance of the fibrillae is also very pale. This hair also contains considerable air in the medulla and a few bubbles scattered throughout the cortex of the shaft. These air bubbles (represented black in the drawings) tend to give the hair a very light tint to the naked eye. The microscopic appearance of the hair of the other dark-race albinos lies between these two types. They are all characterized by the absence of granular pigment and by the more or less intense diffused yellowish colouration of the ground substance of the cells. The only remaining hair on this list is that of the Papuan woman Sanai. She is lighter coloured than an ordinary Fijian but is not a true albino. The microscopic appearance of the hair also resembles that of a normal hair and has not the characters described above for the hair of the dark-race albinos. Plate β, Fig. 4 represents one of her hairs. As will be seen it resembles a normal hair (Fig. 1) in all respects except for the colour of the pigment granules. The absence of pigment granules is such a noticeable feature in all the samples of hair of complete dark-race albinos, that it seems to me that the case of Frédéric's, which he describes as albino and yet contained pigment granules, is probably a similar case of a light-coloured individual and not a complete albino. Thus in the case of the dark races we may conclude that complete albinism is characterized by an absence of granular pigment from the hair and that the colour of their hair is due to colour of the ground substance of the fibrillar cells.

When we turn to the cases of European albinos, or persons having some albinotic features, we find a great variation in the naked-eye appearance of the hair. Most of these are practically colourless, but some are quite dark. In describing these hairs we may, for convenience, divide them into three groups: (1) those colourless, *i.e.* white or practically so, (2) those with slight colour and (3) those with considerable colour. The lines of division between these groups must be more or less artificial, but they serve a purpose in describing the different hairs.

In the first group, *i.e.* those practically without colour or colourless, there are 18 examples of albinotic hair arranged as far as possible in order of the naked-eye appreciation of the amount of colour they possess.

Group I.

		Table (Section B).
1.	A. O. S., Norwegian albino	No. 43.
2.	L. J., English albino, Fig. 411, IV. 3 = C. H. S. (normal)	Nos. 61 and 8.
3.	R. G., Norwegian albino, Fig. 365, III. 6	No. 41.
4.	D. F., English albino, Fig. 86, III. 9	No. 55.
5.	A. F., English albino, Fig. 86, III. 7	No. 56.
6.	T. S., Norwegian albino, Fig. 456, III. 3	No. 52.
7.	I. S., Norwegian albino, Fig. 460, VI. 10	No. 39.
8.	P. S., Norwegian albino, Fig. 460, VI. 10	No. 40.
9.	M. A. M., English albino, Fig. 372, III. 1	No. 50.
10.	M. F., English albino, Fig. 86, III. 8	No. 57.
11.	H. M., English albino, Fig. 87, IV. 1	No. 58.
12.	A. M., English albino (sister to Fig. 87, IV. 1)	No. 59.
13.	A. B., Norwegian albino, Fig. 472, III. 3	No. 42.
14.	W. B., English albino, Fig. 43, VI. 4	No. 60.
15.	Norwegian albino, Fig. 456, III. 2	No. 51.
16.	,, ,, Fig. 456, III. 4	No. 53.
17.	,, ,, Fig. 456, III. 8	No. 54.
18.	English albino, Extra Ped. A, Fig.	No. 123.

In this group one would not expect to find much visible pigment in the hairs under the microscope, and that is the case with all the albinotic hairs. They are characterized by the absence of all pigment granules and by having the ground substance practically colourless or a very faint pale yellowish tint (Plate β, Figs. 5 and 7). Also numerous small air vesicles are seen scattered throughout the cortex and in the medulla if this be present. Opposite the name of L. J., second of the above list, appears the name of C. H. S. This is a normal hair and to the naked eye has practically the same appearance as that of L. J. C. H. S.'s hair may be taken as an example of the very light-coloured hair of young children. With the microscope one finds a few pigment granules and a few air vacuoles, while the ground substance of the fibrillae is practically colourless (Plate β, Fig. 6). We thus see that normal hairs may be as light or lighter to the eye than those of albinos and yet be entirely different as regards the distribution of the pigment.

In the second group, *i.e.* those with a slight colour, there are 11 examples as follows (arranged also in order of the naked eye appreciation of the amount of colour they contain):

Group II.

		Table (Section B).
1.	B. H., Norwegian albino, ? Fig. 366, III. 12	No. 21.
2.	J. S., Scottish albino, Fig. 413, V. 4 = A. M. (normal)	Nos. 49 and 9.
3.	A. A., English albino, Fig. 414, V. 7	No. 46.
4.	T. M., Scottish albino, Fig. 130, IV. 14 = A. P. (normal), Fig. 364, VIII. 22	Nos. 48 and 24.
5.	Albino Papuan girl at Kerapunu (certain hairs). See our pp. 78, 79	No. 20.

		Table (Section B).
6.	M. A., English albino, Fig. 414, V. 10	No. 44.
7.	I. J., Norwegian albino, Fig. 457, III. 2	No. 37.
8.	K. H., Norwegian albino, Fig. 366, III. 7	No. 36.
9.	M. S., Norwegian albino, Fig. 460, VI. 5	No. 38.
10.	V. A., English albino, Fig. 414, V. 8	No. 45.
11.	L. W., English albino, Fig. 197, IV. 2	No. 47.

Placed opposite in the list are the names of two normal people, the colour of whose hair is practically the same as that of the albino.

In this second group there are 11 examples of albinos and two normal individuals. Except for the hair of the first, B. H., all the albinotic hairs of this group are characterized by the absence of granular pigment. This is also true for the hair of A. P., the normal equivalent in the fourth line. These albinotic hairs (Plate β, Figs. 8 and 10) are of the same type as those of Group I., except that the ground substance is slightly more coloured. The hair of the first, B. H., on the other hand, might be classified with those of Group III., as it contains considerable pigment in a granular form (Plate β, Fig. 11), but the pigment is nearly horn coloured and the hair appears to the naked eye very like some of the hairs of the albino negroes. The hair of A. P., a normal child (who, however, has albinism in his paternal stock), is also devoid of granular pigment and resembles in structure these albinotic hairs[1]. In this respect it resembles the hair of a young woman from South Germany described by Frédéric. The hair of A. M., the other normal person in this list, possesses plenty of pigment granules. We thus see that there is a distinct tendency for the hairs of albinotic people to be characterized by the absence of granular pigment. Any colour which they possess is usually due to a colouration of the ground substance of the fibrillae.

In the third group we have the hairs of those persons who have some albinotic feature but yet possess considerable pigment in their hair. Of these we have 12 examples as below:

GROUP III.

		Table (Section B).
1.	E. McM., Scottish incomplete albino, Fig. 22, III. 4	No. 18.
2.	H. S., English albino, Fig. 1, IV. 6	No. 19.
3.	R. G., Norwegian albino	No. 12.
4.	Norwegian albino, Fig. 365, III. 10	No. 15.
5.	,, ,, Fig. 365, III. 13	No. 16.
6.	P. K. W., case of premature whitening of hair	No. 14.
7.	Albino Papuan girl at Kerapunu (certain hairs). See our pp. 78, 79	No. 20.
8.	J. M., Scottish incomplete albino, Fig. 393, IV. 20	No. 13.
9.	Dr C., English albino, beard, Fig. 45, IV. 11	No. 34.
10.	Dr C., ,, ,, head, ,, ,,	No. 35.
11.	L. F., English incomplete albino, Fig. 447, II. 1	No. 11.
12.	Norwegian albino, Fig. 365, III. 15	No. 17.

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[1] Similar cases are those of N. W. (No. 90, Section B) and the child E. from Danby (No. 115 of Section B).

These hairs are quite deeply coloured and appear to the naked eye as deeply coloured as those of the average normal individual. All these hairs except those of Dr C. possess granular pigment. Two of these are represented (Plate β, Figs. 9 and 13). These two are seen to be of the normal type and are represented because they have special interest. All the remaining hairs of this group have a similar structure. The hairs of Dr C. are peculiar. To the naked eye they are quite deeply coloured (reddish brown). Under the microscope the pigment is seen to be confined to the central part of the hair around the medulla. The pigment present is not in a granular form, but the whole ground substance of the fibrillae is impregnated with it (Plate β, Figs. 13 and 14). The hairs also contain much air both in the medulla and in the cortex. The hair of a normal individual (Dr A., a Russian, No. 66, Section B) whose colour resembled that of Dr C. also had a similar appearance under the microscope. It is worthy of note that some of the above list (Nos. 12, 15, 16, 14, 17) have more or less "mouse"-coloured hair. All these possess granular pigment. In looking over the above lists we see that there is a distinct tendency for the hair of albinos to have any pigment they possess as diffused, *i.e.* staining the ground substance of the fibrillae and not deposited in the form of granules between the fibrillae as is the case with most normal hairs. Normal hairs much lighter in colour (*e.g.* that of C. H. S., Section B, No. 8) than all those albinos in Group II., and some in Group III., still possess granular pigment. On the other hand the hairs of one or two normal people were met with which possessed only diffused pigment. In connection with this point one or two hairs are especially interesting. Thus in the case of seven Norwegian specimens, all being more or less albinotic, three (Magnus' albinos, Nos. 15, 16, 17 of Section B) possess considerable pigment and all have granular pigment, while four others (Nos. 51, 52, 53, 54 of Section B) have very little pigment and what is present is diffused. The same is true of the two siblings B. H., No. 21, and K. H., No. 36 (Plate β, Figs. 10 and 11)[1]. The hair of J. M., No. 13, is also interesting, as in her youth she is said to have been a typical albino. Her hair is now quite dark and possesses granular pigment (Plate β, Fig. 12). More interesting still is the hair of the Papuan girl at Kerapunu. Some of her hairs are quite dark and others are very pale. The deeply-coloured hairs have granular pigment, while the pale ones have only diffused and are typically albinotic in their microscopic appearance (Figs. 8 and 9).

A consideration of the development of hair may perhaps give an explanation of the appearance of these albinotic hairs. Hair is developed as a downgrowth from the Malpighian layer of the epidermis. The innermost cells of this downgrowth are transformed into the hair proper. In this transformation the substances of the cell are chiefly converted into keratin and the cells take on a more or less yellowish tint. The cells of foetal hair seem to be more deeply coloured than those of the adult. Plate β, Fig. 15, from a section of human foetal scalp (No. 94), represents the appearance of a piece of the shaft of a hair. It is seen that the ground substance of the cell is as deeply coloured as that in the Papuan albino (Plate β, Fig. 2). Also in the foetal hair we see the pigment granules which normally become deposited between the cells. In the case of many albinos these latter are not formed, so that the only colour present is the colour of the cells themselves. Remembering that keratin itself is white and considering the great variation of colour seen in these albinotic hairs devoid of granular pigment (especially those of negroes), we must consider this yellow colour as a true pigment probably related to, or derived from, a lutein. Furthermore, many of these albinotic hairs have tints which are not yellow. This must be a true pigment and be derived from this yellowish pigment by an alteration of its constitution. Finally, if Spiegler be correct that white hairs contain a true white pigment, this must also be derived by a transformation of this yellow pigment, since white hairs do not contain white granular pigment. From these considerations we may conclude, as has already been suggested by Waldeyer[1], that normal hairs possess two distinct pigments, the one usually in the form of granules deposited between the cells of the hair and the second in the cell itself. The granular pigment is usually present in normal hairs, and has many different shades and tints. The colour in the cells is yellowish, usually very pale but sometimes quite deep. A certain amount of variation from yellow is sometimes met with in some cases, and this cell pigment is probably transformed into white pigment in white hairs.

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[1] A still later case is that of the Syrian albino stock Fig. 597. Here IV. 3 has hair with no granular pigment and few air vacuoles; IV. 31 has no granular pigment and air vacuoles; while IV. 23 has some granular pigment and air in medulla and shaft.

SUMMARY.

In albinotic hair there is a distinct tendency for the hair to be free of granular pigment and possess only the diffuse colouration of the cells. The occasional occurrence of normal people with this same peculiarity detracts somewhat from this feature as a distinct albinotic characteristic.

EXPLANATION OF PLATE β.

Illustrating Dr F. H. Scott's section "On the distribution of the pigment in hair with special reference to that of albinos."

Note.—The drawings were made solely with regard to the pigment of the hair. Except for Figs. 14 and 15 they are from entire, *i.e.* not sectioned, hairs. The drawings were made as seen under a No. 8 objective of Leitz and No. 4 ocular, but in studying the hair as high power as the 2 mm. apochromatic of Zeiss with a 12 ocular were employed.

Fig. 1. Hair of normal Fijian. The hair is seen loaded with black granular pigment deposited in rows between the faint yellowish fibrillar cells. Section B, No. 1.

Fig. 2. Hair of Papuan albino. No pigment granules are seen and no air vacuoles. The colour is due entirely to the colour of the cells. Section B, No. 27.

Fig. 3. Hair of Loraina of Vitogo, a female Fijian albino. No pigment granules present but some air vacuoles (represented black in drawing). Cells faint yellow. Section B, No. 32.

Fig. 4. Hair of Sanai, a Fijian incomplete albino. Brownish pigment granules present. Section B, No. 92.

Fig. 5. Hair of L. J. No pigment granules present, some air vacuoles, cells faint yellow. Section B, No. 61.

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[1] *Atlas der menschlichen u. tierischen Haare*, Lahr, 1884.

Fig. 6. Hair of C. H. S. (normal blond). Pigment granules and air both present. To the naked eye these hairs are hardly distinguishable from those of Fig. 5. Section B, No. 8.

Fig. 7. Hair of Norwegian albino. This is the whitest of all the albinotic hair examined. The cells still have a very faint yellowish tinge. Section B, No. 51.

Fig. 8. Certain hairs of albino Papuan girl at Kerapunu. Compare with Fig. 9. Section B, No. 20.

Fig. 9. Other hairs of the albino child at Kerapunu. Section B, No. 20.

Fig. 10. Hair of K. H., Norwegian albino. Section B, No. 36.

Fig. 11. Hair of B. H. The granular pigment in this hair has much the same colour as that in the cells of many other albinos. Section B, No. 21.

Fig. 12. Hair of J. M. Section B, No. 13.

Fig. 13. Hair from Dr C.'s beard. Only diffused pigment is seen. This hair diverges more from yellow[1] than any other hair met with that only contains the cell pigment. Naturally the hair contains much air both in the medulla and cortex. This is not represented in the drawing which was made after the air had been driven out. Section B, No. 34.

Fig. 14. Transverse section of hair from Dr C.'s beard. Some of the air vacuoles are represented. Section B, No. 34.

Fig. 15. Shaft of hair in scalp of human foetus. Section B, No. 94.

Explanation of Plate κ. The contents of this Plate are discussed under Nos. 1—70 of the Table, Section B.

SECTION D. *Classification of Hairs examined.*

The reference numbers are to those of the first column of Table, Section B.

I. *Hairs with granular Pigment.*

a. **Dark-Skinned Races.**

(i) NORMAL.

No.	Race and State	Nature of Hair. Remarks	Ocular Condition
1, 2	Fijian	Frequent granules, see Plate β, Fig. 1	Normal
71, 72	Syrians	Numerous black granules	,,
98	Nyassa Piebald	Normal hair, thick with pigment granules	,,
96	Nyassa old Woman	Dark hair, large number of granules	,,
10	Russian Jewess	Very blond, frequent granules	,,

(ii) ALBINOTIC.

75	Syrian	Some granular pigment, air in medulla and shaft	Nystagmus, blue irides, dark pupils, see Fig. 597, IV. 23
76	Russian Jewess	A little granular pigment, numerous vacuoles	Nystagmus, blue irides, pink pupils, see Fig. 568, IV. 8
20	Papuan girl	Granular pigment in *some* hairs	Nystagmus, fundi pale, some pigment in both choroid and retina, see our p. 78
70	Gilbert Islander	Two types of hair, dark type has many pigment granules	Described simply as "an albino"

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[1] Macroscopically it was sandy-red.

β. **Light-Skinned Races.**

(i) NORMAL.

No.	Race and State	Nature of Hair. Remarks	Ocular Condition
3	English	Pigment granules, light at 4 years. Very dark or nearly black at 50 (1908)	Normal
4—9	English, blond children	All with pigment granules	,,
91	English, pale red blond	Looks almost albinotic, minute fine granules, but not many	,,
79	English, leucodermatous	Normal hair black, numerous granules	,,

(ii) ALBINOTIC.

77	English, complete	All hairs macroscopically uniform dull white, but some hairs microscopically have faint colour and some granular pigment with numerous vacuoles	Nystagmus, photophobia, red pupils. See Fig. 610, III. 3, and cf. II. *β* (ii) below
11	English, L. F.	Granules, hair now dull brown, once very fair, eyebrows and lashes almost white	Nystagmus, incomplete ocular albinism, Fig. 447, II. 1
12	Norwegian, R. G.	Granules	
13	Scottish, J. M.	Granules, hair quite white as child, now (aged 27) light brown	Nystagmus, red pupils, albinism of choroid and retina, pigment in iris, Fig. 393, IV. 20
14	P. K. W.	Some granules, hereditary premature whitening of hair	Normal
15	Norwegian	Granules	
16	,,	,,	
17	,,	,,	
18	Scottish, E. McM.	Pigment granules, hair in youth light yellow, dark brown later, eye-lashes almost white	"Moving eyes," "short sighted" called "blind fair," photophobic when young, eyes blue. See Fig. 22, III. 4
19	English, H. S., 'Rufous Albino'	Granules, hair light yellowish red, eyebrows and lashes quite white	Eyes fully albinotic (Stanford Morton), see Fig. 1, Plate I.
21	Norwegian	Granules	
22	Scottish, A. M.	Granules, light brown hair	Incomplete ocular albinism. See Fig. 501, V. 16
23	,, M. M.	Granules, hair lighter than brother 22	No nystagmus, fundus very pale, ? incomplete ocular albinism
85	Scottish, deaf-mute Albino	Two varieties: dark tuft on head, thick with granules	Incomplete ocular albinism. See Fig. 649, III. 5

II. *Hairs with only cellular Pigment.*

a. **Dark-Skinned Races.**

(i) NORMAL.

None so far received.

(ii) ALBINOTIC.

No.	Race and State	Nature of Hair. Remarks	Ocular Condition
95	Nyassaland, Nkomo	No pigment granules, marked air vacuoles, wool flaxen	Nystagmus, photophobia, no reflex observed: see p. 166
28	Nyassaland	No pigment granules, wool light straw colour	Nystagmus, photophobia, irides with peri-pupillary hazel, Fig. 430, II. 3
29	"	No pigment granules, wool light straw colour	Nystagmus, photophobia, some yellow pigment in iris, Fig. 427, II. 3
30	"	No pigment granules, wool very light straw colour	Nystagmus, photophobia, irides peri-pupillary orange, Fig. 431, II. 4
31	"	No pigment granules, wool light straw colour	Nystagmus, photophobia, irides slate blue, no marked pigment ring, Fig. 428, III. 3
88	Nyassaland, Bandowa	Wool of scalp, no granules or vacuoles	Photophobia, brown iris and "dark pupils." See Fig. 648, II. 2
89	Nyassaland, Bandowa	Pubic hair, no granules, some vacuoles	
93	Nigeria	No pigment granules, wool light ginger colour	Nystagmus, irides light brown: see p. 135
32	Fijian Albino	No pigment granules, light yellow hair	No details as to eyes, Fig. 485, IV. 2
33	" "	No pigment granules, light yellow hair	No details as to eyes, Fig. 429, IV. 3
20	Papuan Albino	Some hairs free from pigment granules, see I. *a* (ii) above	Nystagmus, fundi pale, some pigment in both choroid and retina: see p. 78
27	" "	No granular pigment, light yellow hair	Nystagmus, photophobia, choroid light, Fig. 348, II. 2
68	Woodlark Islander	No granular pigment, hair flaxen	Photophobia, choroid free of pigment, irides gray blue, Fig. 417, IV. 1
70	Gilbert Islander	Two types of hair, light type no granules and no vacuoles	Reported as a "complete albino": see Fig. 576, IV. 1
74	Syrian albino	No granular pigment, air vacuoles present, hair quite white	No details as to eyes: see Fig. 597, IV. 31
73	" "	No granular pigment, few air vacuoles, brilliant light gold	Nystagmus, blue irides, black pupils, Fig. 597, IV. 3
99	Nyassaland Piebald	Light hair, no pigment granules, very very pale diffused pigment	Eyes normal, Fig. 632 bis, p. 250

β. **Light-Skinned Races.**

(i) NORMAL.

90	English, N. W.	Complete want of granular pigment, extreme blond	Eyes light blue, no nystagmus or photophobia, probably normal
24	English, A.P., aged 4	Complete want of granular pigment, extreme blond	Eyes normal, Fig. 364, VIII. 22
25	" " aged 7	Complete want of granular pigment, extreme blond	" " "
66	Russian	Complete want of granular pigment, hair congenitally gray	"
115	English, E., aged 2	Complete want of granular pigment, very pale diffused pigment	"

(ii) ALBINOTIC.

No.	Race and State	Nature of Hair. Remarks	Ocular Condition
77	English, complete	All hairs macroscopically uniform dull white, some are white microscopically, no granular pigment, numerous vacuoles	Nystagmus, photophobia, red pupils: see Fig. 610, III. 3, and cf. I. β (ii) above
78	Scottish, 'Rufous Albino'	No granular pigment, bright red hair	Nystagmus, fundus albinotic blue gray irides, no pigment in stroma, see Fig. 606, IV. 3
34	English, 'Rufous Albino'	No granules, whole substance of fibrillae impregnated with diffused pigment; reddish brown hair	Complete ocular albinism, Fig. 45, IV. 11
35	English, 'Rufous Albino'		
36	Norwegian Albino	No granular pigment, sister to albino, hair sample No. 21, with granular pigment	Complete ocular albinism
37	" "	No granular pigment	"Albino"
38	" "	" "	Incomplete albinism
39	" "	" "	Complete ocular albinism
40	" "	" "	" " "
41	" "	" "	" " "
42	" "	" "	"Albino"
43	" "	" "	Complete ocular albinism
44	English Albino	Three sisters (see Plate O (44)) with complete albinism of hair, *i.e.* no granular pigment, Fig. 414, V. 10, 8 and 7; for colours see Plate κ, E_{11}, E_{12} and E_{13}	Irides blue, pupils black, occasionally red, choroids light, no nystagmus
45	" "		Nystagmus, irides blue, pupils red, choroids extremely light
46	" "		No nystagmus, irides blue, pupils black, but occasionally red, choroids light
47	" "	No granular pigment, Fig. 197, IV. 2	Lateral nystagmus, typical albino
48	Scottish Albino	" " Fig. 130, IV. 14	Incomplete ocular albinism
49	" "	" " Fig. 413, V. 4	Nystagmus, blue irides, albinotic fundus
50	English Albino	" " Fig. 372, III. 1	Complete ocular albinism
51	Norwegian Albino	Group of four siblings with hair without granular pigment, three other siblings Nos. 15, 16, 17 have granular pigment	" " "
52	" "		" " "
53	" "		" " "
54	" "		" " "
55	English Albino	No granular pigment, Fig. 86, III. 9	As III. 7, typical ocular albino
56	" "	" " Fig. 86, III. 7	Nystagmus, irides very pale, red pupils, complete ocular albinism
57	" "	" " Fig. 86, III. 8	As III. 7, typical ocular albino
58	" "	" " Fig. 87, IV. 1	Incomplete general albinism
59	" "	" " Sister to Fig. 87, IV. 1	Born after pedigree engraved, albinism of like type to IV. 1
60	Irish Albino	" " Fig. 43, VI. 4	Nystagmus, pupils sometimes red, fundus albinotic
61	English Albino	" " Fig. 411, IV. 3	Nystagmus, iris and pupil red, complete ocular albinism
62	Norwegian Albino	" "	Complete ocular albinism
63	" "	" "	
64	" "	" "	
83	Swiss blond from albinotic stock	No granular pigment, no air vacuoles, Fig. 640, VII. 77	Possibly like No. 24, also of albinotic stock: see II. β (i) above, but we suspect some form of incomplete ocular albinism
84	Swiss blond from albinotic stock	No granular pigment, air vacuoles, Fig. 640, VII. 45	

(ii) ALBINOTIC (*continued*):

No.	Race and State	Nature of Hair. Remarks	Ocular Condition
81	Swiss Albino	Two types of hair; white variety, brownish towards end, no granules or vacuoles	Complete ocular albinism, see Fig. 640, V. 65
82	" "	Yellow variety, deeply coloured and somewhat patchy, no granules and no visible vacuoles, but latter difficult to be certain about	
85	Scottish deaf mute Albino	Two types of hair, white or pale yellow variety, no granules or vacuoles	Incomplete ocular albinism, see Fig. 649, III. 5
87	Scottish Albino	Hair white macroscopically, but reddish microscopically, no granules or vacuoles	Complete ocular albinism, see Fig. 642, III. 5
89	Leucodermatous hair	White hair, no pigment diffused or granular, air vacuoles like ordinary white hair	Eyes normal
123	Scottish Albino	No granular pigment, scarcely any diffused pigment	Complete ocular albinism
141	" "	No granular pigment, no diffused pigment, some vacuoles	" " "
142	" "	No granules, no diffused pigment	Complete ocular, Fig. 646, V. 9, the sister, V. 6, has light brown diffused pigment and very plentiful granules (E)

SECTION E. *The Rufous Albino.*

The reader will have noticed somewhat frequent references in this chapter, as well as in earlier chapters, to the association of red hair with albinism. The red hair of certain complete or incomplete ocular albinos made a great impression on travellers in Asia and Africa in the eighteenth century, and in a vague manner some association of red hair and albinism seemed to be indicated. We have had occasion to refer to the appearance of red-haired negroes (see our pp. 130, 165—166, etc.), red-haired Malaysians (pp. 64, 65), red-haired Papuans (see pp. 74, 76, 80), red-haired Chinese (see our p. 161) and red-haired American Indians (see our p. 164). It was not unnatural at first to consider these as cases of imperfect albinism, but the microscopic examination of red hair seems to indicate that it can be as free from granular pigmentation as the whitest of albino hairs. Much more recently the existence of the "rufous" albino has been established among the light-skinned races. We have already noticed Furnari's reference (see p. 170) to Jewish albinos with red or reddish hair, and Ernst's case of Regina Jordan (see Bibl. 193, 1830) seems to be that of a rufous albino[1]. Later (1879) we have the noteworthy case of Folker, who found three albinos in a sibship, all with complete ocular albinism, two with white hair, but the third with *red* hair. It is highly probable that the hair of the latter was as completely wanting in granular pigment as those of the former, and the distinction between complete and incomplete albinism in this family may not be justifiable. The following is a list of the rufous albinos, probably not quite complete, from our pedigrees:

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[1] Raffenel met at Sambougan a red-haired, red-skinned, red-pupilled albino negro. It is of interest also to remember that Pruner Bey (see Bibl. No. 98), p. 273 and others have noted that dark Spaniard and American Indian can produce red-haired offspring, which appears as another instance of a pigment breakdown following hybridisation.

Pedigree and Index Number	Nature of Hair	Ocular Albinism
Fig. 1, IV. 6: see (19), Section D	Bright yellowish red, *some granules*	Eyes fully albinotic
Fig. 40, IV. 4	Russet-brown	Nystagmus, choroid very deficient in pigment, iris blue gray
Fig. 45, IV. 11: see (34, 35), Section D	Sandy hair and beard, *no granules* (hair also described as reddish brown)	Complete ocular albinism
Fig. 82, IV. 2	Now sandy, once white	Said to be incomplete albino
Fig. 94, II. 3	Medium reddish brown	Eyes completely albinotic
Fig. 230, II. 2	Red hair	Albinotic eyes
Fig. 310, II. 3	Reddish hair	Iris blue gray, choroidal vessels visible all over fundus except in yellow spot region
Fig. 395, II. 1	Sandy hair	Blue gray irides, very slight nystagmus, choroids almost albinotic
Fig. 446, II. 7 (Jew)	Light rusty colour	Incomplete ocular albinism
Fig. 497, IV. 10	Light yellow red	Ocular albinism, ? incomplete
Fig. 540, III. 20	Red yellow	Reported complete albino
Fig. 557, II. 8	Ash blond, reddish beard	Albinism, ? incomplete
Fig. 565, IV. 38	Sandy-gray	No nystagmus, pupils red, iris blue, fundus albinotic
Fig. 575, IV. 15[1]	Light brown, sandy tinge, ginger moustache	Incomplete albinism, fundus very albinotic
Fig. 606, III. 4	Light yellow, moustache yellow red	Incomplete ocular albinism
Fig. 606, IV. 3: see (78), Section D	Red, *no granules*	Iris blue gray, no pigment in stroma, constant nystagmus, fundus albinotic

Of these 16 cases the eyes are reported fully albinotic in five cases, and with various degrees, approaching to complete albinism in some cases, in the remainder. We have unfortunately been able to examine the hair in only three of these cases; in the two cases in which the eyes were said to be fully albinotic there were some pigment granules in one (Fig. 1) and no pigment granules in the other (Fig. 45). In the case where the albinism of the eye was not quite complete, the brilliant red hair contained no pigment granules (Fig. 606). We have excluded from our Table all reported cases of red-haired albinos from the dark and black-skinned races; further, all albinos, whether from European or other races, reported to have golden or yellow hair. Such hair is almost invariably without granular pigment, and is so frequent that it is not possible to make it a characteristic of a differentiated class of albinos. But we think that the existence of a rufous type of albino is demonstrable. This type may have as type characters complete ocular albinism and bright red hair without granular pigment, but as in all other types of albinism we have come across, these type characters are only rarely fully represented, we shall find on careful examination almost every grade of ocular albinism, and granular pigmentation may be present in small or even fair quantities.

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[1] Possibly IV. 17 and IV. 24 ought also to be classed as rufous albinos. Albinos with "golden" hair occur in Figs. 10, 39, 89, 370, 376, and 539; these probably mean "yellow red."

The existence of these rufous albinos[1] at once raises the question of whether there is any special relation of albinism to red-haired stocks, and some investigation of this matter has been made from several independent sides.

(i) *Prevalence of Red Hair in Albinotic Stocks.* The material here must be of a rather rough character, because only verbal descriptions have been taken of the hair, and these are often based solely on the accounts of relatives. Still these accounts are likely to under-estimate rather than over-estimate the prevalence of red hair. Thus where a careful observer notes a *red-blond*, the casual observer often merely states *fair hair.* Again it is not unreasonable to suppose that some of the "brownish hair," "very dark brown hair" and even "blacks," which are very frequent in the parents, may be "chestnut reds" or "black chestnuts." We have omitted, of course, all such from our reds and included them in the not reds. Further, as many pedigrees give the hair and eye colour only of those most closely related to the albinos, we have confined our attention to (i) the brothers and sisters of albinos, (ii) the parents of albinos, (iii) the uncles and aunts of albinos. This provided 286 of the white race albino stocks which could be tabled. This range of relationship by no means exhausts the occurrence of red hair in the stocks. In fact it was the general large frequency of red hair in the pedigrees which first concentrated our attention on the matter. Thus in six stocks we were told that "some" or "several" uncles or aunts had red hair and these could not be included. In 36 out of the 286 pedigrees, red hair occurred in the higher ancestry or collaterals. For example, red hair is prevalent in Figs. 12, 25, 45, 312, 497, 501, 531, 535, 596, 636, 639 and 640 (Cornaz's Chassot-Rey family). In Figs. 137, 180 and 636 red hair occurs in a grandparent and, in other than parents, brothers, sisters, uncles and aunts of the albinos in 10, 23, 27, 28, 29, 30, 31, 32, 43, 46, 145, 256, 368, 391, 413, 450, 456, 480, 563, 566, 605 and 637. Indeed a rapid survey of our Appendix of pedigree descriptions will suggest to the reader that the relation of red hair to albinism can hardly be fortuitous.

In the following data "albino" covers both complete and incomplete cases, as the distinction does not seem of importance for our present purpose.

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[1] The existence of such albinos was, perhaps, first pointed out by Seiler (see Bibl. No. 201, S. 47) in 1833 in the case of Wilhelmine Steude who had yellow red hair combined with nystagmus, photophobia, myopia, light gray-blue irides and *violet* pupils. Cornaz, citing Rau (see Bibl. No. 236) and von Ammon (see Bibl. No. 231), associates (see Bibl. No. 256, p. 296) imperfect albinism with hair varying from white to clear red. But, as we have seen, the rufous albino has not necessarily incomplete ocular albinism. In the two cases of *leucosis imperfecta* cited by von Ammon, the one is stated to have had hair with a green appearance (*grünlichen Schein*) and the other fairly dark (*ziemlich dunkel*) hair; the information in both cases is thus not very enlightening. Rau contributes nothing to the hair data. It is not obvious therefore where Cornaz drew his *roux clair;* it may have been from personal observation, but as a rule he states full particulars of the cases he has himself seen.

Relative of Albino	Hair				Total Cases	Percentage of Red Hair	
	Red		Not Red				
	Albino	Normal	Albino	Normal		With Albinos	Without Albinos[1]
Parent	2	59	25	410	496	12·3	13·0
Siblings	25	78	595	693	1391	7·4	12·9
Uncles and Aunts	0	60	37	637	734	8·2	8·6

The question now arises as to whether these percentages represent more than the amount of red hair to be found in the normal white-skinned population. Now surveys of school children and of recruits have shown that the red-haired are in Prussia 0·3 °/₀; in Baden 0·7 °/₀; in Italy 0·6 °/₀; and in Sweden 0·3 °/₀. Among the school children of Great Britain Pearson found 3·7 °/₀. Tocher found among the insane of Scotland 1·95 °/₀ and among the school children 5·22 °/₀. It is possible that in certain districts of Ireland or Scotland the percentage of all ages may run up to 4 °/₀[2]. It will be seen that our values, which are certainly no maximum values, are much beyond the observed percentages of red hair in the general community, and we are compelled to conclude that not only does a rufous albino exist, but that albinism is in some manner more closely associated with rufous than with other stocks.

This association suggested further investigation. It is known that the skin of the rufous individual is generally pale and shows a marked tendency to freckle[3]. Now we have already dealt with the remarkable freckling of the albinos

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[1] This excluded white or fair-haired albinos, but includes the red-haired albinos when determining the percentages.

[2] Owing to the kindness of Dr Hunter of the Royal Albert Asylum, Lancaster, we are able to give the following data of the prevalence of red hair among imbeciles:

	Total	All Reds	Fair Red	Fair with Red Tinge	Bright Red	Dark Red	Percentage
Boys	444	26	4	1	16	5	5·86
Girls	237	17	6	2	4	5	7·17

These percentages appear to be considerably in excess of those in the general population.

[3] We owe the following data to the kindness of Professor R. W. Reid, who has given us permission to use this material taken from the Anthropometric Laboratory, Aberdeen University. Of the 915 persons examined, 656 were medical students, 185 were policemen and 74 attendants in an asylum.

Two points are made clear by this table: (i) that the amount of freckling in dark, brown, and fair-haired persons is practically the same, and probably the same as in black-haired persons. Even should the latter on larger numbers prove somewhat greater, it may well be due to the fact that red appears to be a factor of some black-haired cases. And (ii) that the amount of freckling in red-haired persons is of some dark-skinned races (see our Plates, photographs (64)—(68))—a freckling that can become so conspicuous that they have been mistaken for piebalds. We have already (pp. 54—57) discussed this freckling, and have had to admit that—although our inquiries on the point began late—it appears to occur among the Copts and Syrians or incomplete European albinos rather than among the complete European albinos[1]. At the same time Cornaz's albino infant (Fig. 316, III. 2) seems to have combined freckles with complete albinism. In many recent inquiries freckling was distinctly denied (*e.g.* Figs. 45[2], 414, 450, 532, 540, 596, 639, 642). The resemblance, therefore, in the matter of freckling between the rufous and the albinotic is rather between the incomplete and dark-skinned albino and the rufous person than between the latter and the complete European albino. It will hardly be explained until a fuller microscopic and chemical knowledge is reached of the nature of the freckle pigment in both rufous person and dark-skinned albino.

(ii) *Direct Investigation of the Hair and Fundus of Rufous Individuals.* We were able, owing to the kindness of Mr N. Bishop Harman, to obtain samples of the hair of 25 red-haired children for microscopic examination. In the case of these, mostly London, school children, he has recorded the colour of the irides, the apparent degree of pigmentation of the choroid and in most instances the refraction. At the same time he has provided for comparison like records, and in addition the visual acuity, of 25 rather light-haired persons, mostly school children, and of 22 unselected congenital deaf-mutes. In the latter case the whole school was taken; in the former the first 18 light-haired children were taken in order of appearance.

In the description of the aspect of the fundus: *A* means a fair or blond choroid where the interspaces are usually so slightly pigmented as to be of lighter colour than

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five times as great as in the other categories. This confirms the current opinion and gives it quantitative measure.

Hair Colours.

	Black	Dark	Brown	Fair	Red	Total
No. of Cases	18	208	391	256	42	915
Percentages	2·0	22·7	42·7	28·0	4·6	100
No. of the freckled	1	9	17	11	9	47
Percentage freckled	5·6	4·3	4·3	4·3	21·4	5·1

Freckling was also observed for us by Mr Bishop Harman. Among 24 rather light-haired people, 6 or 24 °/o were freckled; among 24 red-haired people, 15 or 67·5 °/o were freckled; and among 17 deaf-mutes not selected for red or light hair only 2 or 11·8 °/o were freckled. The numbers are of course very small, but the great increase in the percentages of freckling over Professor Reid's cases is probably due to the fact that Mr Harman's data refer almost entirely to *children* and Professor Reid's to *adults.* The fundamental point, however, the great preponderancy of freckling with red hair, is confirmed.

[1] See Figs. 316, III. 2; 492, IV. 5; 497, IV. 10; 501, V. 16; 535, IV. 18; 565, IV. 38; 597, IV. 3 and 34; 599, IV. 2, 3, and 4; 611, III. 1.

[2] See ftn. on our p. 56.

the blood vessels—an approach to the appearance of albinism. This is the usual condition at birth, the choroid containing little or no pigment then or for some time after; the choroid becomes gradually pigmented, but we do not know when the process stops or whether there is any constant age after which it ceases. *B* means a fundus in which the general pigmentation of choroid and hexagonal (retinal) epithelium is of about the same depth of intensity as the choroidal vessels, so that the latter are not visible as such; a medium fundus. *C* means that the spaces between the choroidal vessels are so highly pigmented as to be darker than the vessels; a dark or richly pigmented fundus. Among the red-haired children, Cases 1—16 were all in a "higher grade" school and were examined at the same time. The refraction was obtained by retinoscopy under mydriatic, corrected to infinity. The microscopic examination of the hair was made by Miss E. Y. Thomson. In this examination, α embraces "one or two granules," "hardly any granules," or "very few," and represents *very few*. β embraces "quite a few scattered granules," $\gamma =$ a "decided number of granules," "a fair number of very small granules." α—β is the transitional "few granules" and β—γ the "rather more than β." The hair samples placed in order of microscopic appreciation of granular pigmentation run as follows: 17, 20, 13, 8, 2, 11, 10, 3, 15, 9, 12, 5, 19, 7, 21, 14, 1, 18, 6, 23, 24, 16 and 4. (There was no sample of 22.) Even in 17 one or two granules were found, but there was no extreme frequency of granules even in 4. Certain other red hair samples (see our p. 330) examined both by Dr Scott and Miss Thomson have been entirely wanting in granules. Thus there seems to be a considerable want of granular pigmentation in the red-haired. The numbers dealt with are not sufficient to be final, but they are very suggestive, although the percentages must be subject to large probable errors:

Nature of Fundus

Class	*A*	*A—B*	*B*	*B—C*	*C*	Total
Light Hair	3	—	18	2	2	25
Red Hair	5	1	9	4	6	25
Deaf-mutes	6	1	6	3	6	22
Light Hair	12 %		72 %	16 %		*Percentages*
Red Hair	24 %		36 %	40 %		
Deaf-mutes	32 %		27 %	41 %		

Thus moderate pigmentation of the fundus seems to be the essential feature of light-haired individuals. Among red-haired individuals this moderate category is reduced to half of its value among light-haired individuals, but the increase is not wholly in the darker pigmented class but in the fundi with an approach to the appearance of albinism. Thus it would appear that the red-haired class is markedly differentiated from the blonds, having a much lesser tendency to the intermediate class of choroid. Finally, if we examine the deaf mutes we find this tendency still further evidenced; with the same number of deeply pigmented fundi as the red-haired category, the medium class is still further diminished and the semi-albinotic choroids proportionately emphasised.

TABLE A. *Particulars of 22 Red-haired Children and 2 Adults.*

Index No.	Sex and Age	Freckles	Hair		Irides	Fundus	Refraction	Father		Mother		Siblings	
			Macroscopic	Microscopic				Hair	Eyes	Hair	Eyes	Hair	Eyes
1	♀, 8	a few	red auburn	β—γ	brown red on blue green	*C*	H. 3 D.	red	blue	black	brown[3]	♂, red ♀, v. dark ♀, not red	— — —
2	♀, 7	a few	rather redder than 1	α	brown red on blue	*C*	H. As. 4·5 D.	red	blue	black	brown		
3	♀, 9	freckled	red auburn	α—β	bright blue	*B*	slight H.	red	—	d. brown	blue, brown speckling	♀, dark	—
4	♀, 10	none	brownish red	γ	bright blue with yellow tinges	*B*	Myopic	dark	brown	red, when young	dark brown	o, dark o, flaxen	— gray
5	♀, 12	few	brownish red	β	bright blue with yellow tinge	*B*	H. 1·5 D.	red	blue	dark	hazel	♀, v. fair ♂, brown ♂, fair	— blue blue
6	♀, 9	very few	red brown	γ	bright clear blue	*A*	H. 1 D.	red	blue	v. d. brown	blue green[3]	♀, fair ♂, fair ♀, d. brown	blue blue blue
7	♂, 12	none	dark red brown	β	R. clear blue L. yellow on blue	*B*	H. 1 D.	red	blue	v. d. brown	blue green		
8	♀, 8	a few	rich copper red	α	copper brown	*C*	Em.	dark	hazel	v. d. brown	d. red brown	o, dark ♀, dark ♀, red brown	— brown brown
9	♀, 11	good deal freckled	light brown red (? old gold)	β	hazel, pale yellow on blue	*B*[1]	Em.	red brown	gray green	d. brown	hazel	♂, flaxen	blue
10	♀, 12	none	light bright red (? orange)	α—β	bright blue	*B*—*C*	H. As. 1·5 D., 2·5 D.	d. black	brown	black	brown	♂, brown ♀, fair ♀, red	brown blue blue
11	♀, ?	none	red auburn	α—β	pale hazel	*B*	slight H. As.	fair	brown	v. d. brown	hazel	none	none
12	♀, 9	freckled	brown gold	β	R. blue, L. blue with brown sector 'up-out'	R. *B*, L. almost *C*	H. 2·5 to 3 D.	d. brown	hazel	d. brown	pure blue	♀, same hair and eyes	
13	♀, 9	few	uniform bright red	α	rich dark brown	*C*	slight H.	brown, was red	blue	d. brown	d. brown hazel	♂, like mother ♀, d. red	 blue gray
14	♀, 12	some	sandy or reddish brown	β—γ	greenish blue	*C*	R. slight My., L. Em.	nearly black	brown	d. brown	hazel	♂, brown ♂, fair	brown blue
15	♂, 9	very few	dark copper or auburn	α—β	pure blue	*B*	considerable My. and Astig. more of both in L. than R.	"black"	?	"black"	?	♂, red	—
16	♂, 13	very few	reddish brown	γ	bright blue	*B*, almost *A* at periphery	Low My. Ast.	d. brown	gray	nearly black	pure blue	none	none
17	♀, 11½	freckled	bright red	α (one or two granules only)	pale green	*B*	Vision $\frac{6}{18}$		Parents? A waif. Three siblings				none red
18	♀, 10¾	none	dark or auburn red	β—γ	brown	*C*	no record		Parents? A waif. One sibling				no record
19	♂, 11[2]	none	rather light red, brows and lashes yellow	β	blue with yellow pigment at pupillary border	*A*	Low H. with slight Ast.		No family history recorded				
20	♀, 8[2]	none	bright red, brows and lashes reddish brown	α (one or two granules only)	brown	*B* (? *C*)	no record	?	?	dark	?	♀, d. brown	?
21	♂, 23	none	bright red, brows and lashes yellow	β—γ	reddish brown	*B*	Em.	dark	—	dark	—	4 ♂ s, red 3 ♀ s, dark	—
22	♂, 8	large red freckles	auburn red	no sample	blue brown at pupillary margin	nearly *A*	H. 5 D.			No details of family			
23	♀, 10[2]	none	copper red, pale lashes	γ	yellow green	*A*, patchy then almost albinotic	?			No details of family			
24	♀, 26	few	auburn	γ	bright blue, tinge of yellow at margin	*B*—*C*	My. 5 D.	d. brown	gray	d. brown	d. brown	3 ♀ s, d. brown 1 ♂, d. brown	d. brown d. brown
55	♀, 14	?	bright red, lashes straw colour	γ	clear blue	*A*	slight My. Ast.			No details of family			

[1] 9, some "mole" or "wart" congenital pigment spots and cilio-retinal vessels.

[2] 19, 20 and 23 are deaf-mutes, 19 and 20 mentally defective. 23, teeth honeycombed.

[3] 1 and 2, 6 and 7 are pairs of siblings.

TABLE B. *Particulars of 22 rather Light-haired Children and 4 Adults.*

Index No.	Sex and Age	Freckles	Hair		Irides	Fundus	Refraction	Vision	Remarks
			Macroscopic	Microscopic					
25	♂, 12	none	ash-brown, dark brows and lashes	δ (y. b.)	hazel	*B*	H. 2·5 D.	6/12	Some blepharitis
26	♂, 10	some	medium brown, lashes darker, brows lighter	γ, *m* (v. p. y.)	hazel	*B*	H. 3 D.	R. 6/9, L. 6/6	
27	♂, 10	none	medium brown, lashes and brows same	γ, *m* (p. y.)	brown or green	*C*	R. slight H. Astig.*, L. slight H. Astig.	R. 6/36, L. 6/18	* Oblique normal axes
28	♂, 10	none	ash-brown, lashes and brows thin and light	γ, *s* (p. y.)	bright brown or green	*C* *	slight H.	6/6	* Extreme periphery choroidal vessels dimly seen
29	♂, 9	none	ash-brown, lashes and brows darker	γ, *s* (v. p. y.)	yellow brown, L. darker than R.	*B*	slight H.	6/6	
30	♂, 9	none	light ash, brows same, lashes darker	α, *m*, *i* (?)	gray blue	*B*	slight H.	R. 6/9, L. 6/6	
31	♂, 11	none	ash, lashes same, brows lighter	γ, *m* (?)	blue	*B*	Considerable Mix. Astig.*, R.: M. 1 D., H. 3 D.; L.: M. 1·5 D., H. 2·5 D.	R. 6/18, L. 6/36	* Oblique normal axes
32	♂, 12	none	dull ash, brows and lashes same	δ, *s* (b. y.)	blue	*B*	slight H. Astig.	6/6	Both parents Hebrew
33	♂, 13	soft broad freckles	ash-brown, brows lighter, lashes darker	δ (p. y.)	bright blue	*A*	H. Astig., R.: H. 1·5 D. vert., 5 D. horiz.; L.: H. 2 D. vert., 5 D. horiz.	6/18	
34	♂, 14	none	dark ash, lashes and brows same	ε, *s* (b. y.)	bright blue	*B* *	slight H.	6/6	* Choroidal vessels seen in periphery
35	♂, 10	none	ash-brown, lashes darker, brows lighter	ε (p. y.)	blue	*B* *	R. Em., L. slight H.	6/12	* At periphery = A.
36	♂, 10	few soft yellow freckles	flaxen	δ, *s* (v. p. y.)	bright blue	*A* ? *	slight H.	6/9	* Not *extremely* fair choroid
37	♂, 11	faint	pale ash-brown, lashes same, brows lighter	β, *i* (?)	blue, faint yellow margins	*B*	slight H.	6/6	
38	♂, 11	none	medium brown, lashes and brows same	γ, *i* (?)	blue, yellow margin	*B*	slight H.	6/6	
39	♂, 11	none	ash brown, brows and lashes same	γ (p. y.)	greenish	*B* *	R. slight My. Astig., L. slight H.	6/9	* Curious fluffy appearance round discs, some degree of "opaque nerve fibres"
40	♂, 13	none	dark ash-brown, brows and lashes same	ε* (?)	blue, yellow surface pigment	*B—C*	slight H.†	6/12	* Plenty of granules, in some hairs very plentiful † Corneal nebulae from ulcers
42	♂, 10	very few	ash-brown, brows and lashes same	ε (b. y.)	blue	*A*	R. mod. Mix. Astig., normal axes, L. slight H.	6/12	
43	♂, 11	none	bright brown*, almost colourless lashes and brows	γ, +*v* (v. p. y.)	pale blue	?	slight H.	6/6	* Boys call him "ginger," never "carrots"

* or † refer to Remarks' column.

44	♀, 13	none	light brown	δ (p. y.)	bright blue	*B*	H. 2 D.	6/6	
45	♀, 14	none	light brown, almost a trace of red	δ (v. p. y.)	bright blue	*B*	slight H.	6/6	
46	♀, 19	?	darkish brown, touch of ash	δ, *s* (v. p. y.)	blue, with yellow-brown inner margin	*B*	slight H.	6/6	
47	♀, 6½	?	darkish brown, touch of ash	δ (b. y.)	brown, round inner margin, green next zone, blue basis	*B* *	R.: H. 4 D. vert., H. 7 D. horiz.; L.: 5 D. vert., 9 D. horiz.	?	* Nystagmus and head nodding, no pathological conditions, probably due to error of refraction
48	♂, 26	none	palest ash, marked fairness	δ (y. b.)	bright blue, tinge of yellow at inner margin	*B—C* *	slight H.	6/6	* Quite dark at disc
49	♀, 30	none	very light brown, ? ginger	β (v. p. y.)	bright blue	*B* *	slight H. Astig	6/6 partly	* Extreme periphery choroidal vessels seen, but ample pigment
50	♂, 21	none	ash-brown	β, +*v* (p. y.)	bright blue, yellow margins	*B*	slight Astig. and low H. in both	6/9	
51	♂, 8	few big yellowish splashes	moderate brown, rather patchy	γ—δ (b. y.)	brightest and clearest blue	*B* *	R.: H. 3·5 D. vert., H. 7 D. horiz.; L.: H. 3 D. and 5 D. axes oblique	6/24	* Healthy, extreme periphery choroidal vessels can just be seen

In this table as in A, α=hardly any, or very few granules; β=quite a few granules; γ=a decided number of granules; δ=plenty of granules; ε=granules very plentiful; ζ=densely packed granules. +*v* marks the presence of vacuoles; *s* denotes that the granules are small, *m* that they are very small or minute, *i* that they exist but are faint or indistinct. The letters in brackets refer to the diffused pigment, p. y.=pale yellow, v. p. y.=very pale yellow, y. b.=yellow brown, b. y.=bright yellow and b. p. y.=bright pale yellow. ? denotes that the diffused pigment was very slight, or imperceptible. The examination of the diffused pigment of the hairs was made under a $\frac{1}{8}$th Zeitz and a $\frac{1}{12}$th oil immersion. Thus a macroscopic appearance of slight colour is compatible with no appearance of diffused pigment microscopically.

TABLE C. *Particulars of 22 Deaf-mutes*[1].

Index No.	Sex and Age	Freckles	Hair		Irides	Fundus	Refraction	Vision	Remarks
			Macroscopic	Microscopic					
19	♂, 11	none	rather light red, brows and lashes yellow	β	blue with yellow pigment at pupillary border	*A*	low H. with slight Astig.	?	No family history recorded
20	♀, 8	none	bright red, brows and lashes reddish brown	α (one or two granules only)	brown	*B* (? *C*)	no record	?	One ♀ sibling normal
23	♀, 10	none	copper red, pale lashes	γ	yellow-green	*A*, patchy, thin, almost albinotic	?	?	No family history recorded
52	♀, 13	some	dark brown, fine dark lashes and brows	δ (r. b.)	middle blue, dark behind, light tissue in front	*A*	very slight H.	6/9	No family history recorded
53	♀, 13	none	medium brown	γ, +*v* (b. p. y.)	blue with yellow surface pigment	*C*	H. 3·5 D.	6/6	Siblings: 2 ♂, 4 ♀, none deaf-mute
54	♀, 13	none	lightish brown	γ, +*v* (p. y.)	pale blue, yellow inner margin	*B**	?	6/6	Siblings: 2 ♂, 3 ♀, none deaf-mute * Pigment at edge of discs
55	♀, 14	?	bright red, lashes straw colour	γ, +*v* (b. y.)	clear blue	*A*	slight My. Astig.	6/12	No family history
56	♀, 12	none	bright brown, no ash tone	δ (b. y.)	clear brown	*C*	R.: H. 1·5 D. and 2·5 D.; L.: H. 1 D. and 3 D., both oblique axes	6/18	Siblings: 4 ♂, 3 ♀, none deaf-mute
57	♀, 13	none	very dark ash-brown	ε (b. y.)	rich brown	*A**	H. 2 D. vert. and 2·5 D. horiz.	6/9	Siblings: 1 ♂, 2 ♀, none deaf-mute * Yet marked pigment ring to both discs
58	♀, 14	some	dark rich brown	β, +*v* (p. y.)	middle brown	*C*	slight H.	6/6	Siblings: 3 ♂, 2 ♀, none deaf-mute
59	♀, 13	none	dark ash-brown	δ (b. p. y.)	pale greeny brown	*C**	slight My. Astig.	6/9	Sibling: 1 ♂, not deaf-mute * Very dark
60	♀, 14	none	extremely dark ash-brown, almost "black" but not jet black hair	ε (r. b.)	pale blue, yellowish tinge to margin	*B*	slight H.	6/6	Siblings: 6 ♂, none deaf-mute
61	♀, 15	none	dark brown	ε (r. b.)	gray	*B*	R.: H. 1 D. vert. and 4 D. horiz.; L.: H. 1 D. vert. and 3·5 D. horiz.	6/9	No family history
62	♀, 14	none	medium brown	δ (p. y.)	clear pale blue	*A*	high My. Astig. 5 D., axes oblique	6/9 with correcting glasses	Siblings: 4 ♂, 1 ♀, none deaf-mute
63	♀, 14	none	medium brown	δ (p. y.)	brown on blue	*C*	Em.	6/6	Sibling: 1 ♀, not deaf-mute
64	♀, 15	?	very dark brown, very dark lashes	ε (y. b.)	blue	*B*—*C*	R.: H. 3 D. vert., 4 D. horiz.; L.: H. 2 D. vert., 3·5 D. horiz.	6/9	Siblings: 2 ♀, neither deaf-mute
65	♀, 15	?	medium to dark brown	ε (r. b.)	yellow brown ("cat's eyes")	*B*	H. Astig. 3 D.	6/9	Siblings: 4 ♂, 3 ♀, none deaf-mute
66	♀, 13	none	light brown, very dark lashes and brows	ε (b. y. b.)	middle blue	*A*—*B**	H. Astig. 2·25 D.	6/9	Siblings: 6 ♂, 3 ♀, none deaf-mute * Fundus patchy, part A, other part nearly B. Fuchs' coloboma to each disc
67	♀, 16	?	dark brown	ζ (r. b.)	rich dark brown	*C*	R.: H. Astig. 3 D., axes oblique, L.: lost by accident from stone	6/9	Siblings: 3 ♀, none deaf-mute
68	♀, 16*	?	dark brown	δ (b.)	inner margin yellowish, outside blue	*B*—*C*	R.: H. 5 D.; L.: H. 6 D.	6/6	Siblings: 1 ♂, 2 ♀, not deaf * Deaf-mute from age 4, no known disease
69	♀, 15	none	dark brown	ε (p. y.)	inner yellow, outside blue	*B**	slight H.	6/6	Siblings: 3 ♂, 7 ♀, of which 1 ♂ and 1 ♀ deaf-mutes * Choroidal vessels in periphery dimly seen
70	♀, 15	none	very dark brown	ε (b.)	inner brown, outside blue	*B*	H. 4 D.	6/6	Siblings: none whole, 2 ♂, 3 ♀, half by father, none deaf-mute

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[1] All congenital, except No. 68.

In addition to the symbols defined under Table B, we have: r. b. = red brown diffused pigment, and b. = brown.

Macroscopically the intensity of colour in the hair samples is precisely in the order in which we have placed them, *i.e.* Light Hair, Red Hair and Deaf-mutes, the last group containing many very dark hairs as well as more than its proper or normal percentage of red hair. Thus we see that in broad groups like these the macroscopic appearance of the hair is not a safe test of the pigmentation of the choroid. If we turn to the microscopic appreciation of granulation we have the following results:

Frequency of Granules.

	α	$\alpha—\beta$	β	$\beta—\gamma$	γ	$\gamma—\delta$	δ	ϵ	ζ	Totals
Light Hair	1	—	3	—	8	1	9	4	0	26
Red Hair	5	4	5	4	6	—	—	—	—	24
Deaf-mutes	1	—	2	—	4	—	6	8	1	22

Percentages.

	α, $\alpha—\beta$, β	$\beta—\gamma$, γ, $\gamma—\delta$	δ, ϵ, ζ
Light Hair	15·5 %	34·5 %	50 %
Red Hair	58 %	42 %	0 %
Deaf-mutes	13·5 %	18 %	68·5 %

We see from these results that red hair has far less granular pigment than samples of fair hair, and that the deaf-mutes have a defect of medium granulation, having almost the same percentage of slight granulation cases as the light hair, but an excess of cases of many granules. This, again, is not in accord with the macroscopic appearance of these hairs, nor entirely in accordance with the results for the fundus. It seemed, therefore, worth while to test from the whole material the degree of association of paleness of fundus and granulation of hair. This is given by the following Table, where, considering the paucity of material, it did not seem advisable to make more than threefold divisions of each character.

Nature of Fundus.

		A, $A—B$	B	$B—C$, C	Totals
Granules in Hair	α, $\alpha—\beta$, β	2 {4·44}	11 {9·76}	8 {6·80}	21
	$\beta—\gamma$, γ, $\gamma—\delta$	6 {4·64}	9 {10·23}	7 {7·13}	22
	δ, $\delta—\epsilon$, ϵ, ζ	7 {5·92}	13 {13·01}	8 {9·07}	28
	Totals	15	33	23	71

In brackets are placed the numbers to be expected if the fundus and hair granulation were independent characters. We see that the deviations are not very large, there being, however, an excess of hairs with small granulation having normal fundi and an excess of much granulated hairs with light fundi, *i.e.* the normal-eyed fair-haired folk, and the dark-haired deaf-mutes with rather pale fundi. This shows that for this heterogeneous material there is actually a *negative* correlation[1] between extent of granulation and paleness of fundus. The material is much too slender to deal with this question in the three component groups independently, but it would be well worth considering on a large mass of unselected material, in which macroscopic dark hair would be directly represented in its full proportions, and not only indirectly as a component of the deaf-mute group. Taking, however, such evidence as the material provides, it is not in favour of a *high* association between pigmentation of fundus and granulation of the hair. The 11 slightly granulated light-haired folk and the 15 heavily granulated deaf-mutes compare as follows with regard to fundus:

	A, A—B	B	B—C, C	Totals
Light-haired: α, α—β, β, β—γ, γ	0	9	2	11
Deaf-mutes: δ, ϵ, ζ	4	5	6	15

a result showing no marked relationship of the slightly granulated hair to the lightest fundi[2].

We cannot therefore at present assert that where the fundus tends to be albinotic there the hair will generally have fewer pigment granules. The nexus between albinism of the eyes and albinism of the hair does not on the basis of the present material seem to lie in the existence generally of a very high degree of association between the pigmentation of the fundus and that of the hair. Certain cases with few or no granules in the hair appear to have well pigmented fundi, and other cases of defective fundus pigmentation have quite extensive granular pigment in the hair. In the red-haired group, *as a whole*, however, there does appear to be a marked association between want of granules in the hair and light fundus. And it is to this group that we must apparently first look for light on the nexus between the two found in albinism in man and the lower animals.

Thus the results reached in this section appear to confirm those previously adduced, and suggest that there is really a link between the red-haired and defective pigmentation, but within the group of the red-haired there is no marked *individual* correlation between absence of granular pigment in the hair (a) and paleness of choroid (A).

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[1] Taking the divisions so as to keep positive and negative contingencies together we have $\begin{array}{c|c} 2 & 19 \\ \hline 13 & 37 \end{array}$ for our fourfold table leading to $r = -\cdot 34$; uncorrected contingency gives ·19, both subject to large probable errors.

[2] The occurrence of four deaf-mutes with light fundi is not we believe accidental; at the same time it emphasises our argument that the eye and hair associations are not very close, because these light fundi occur with the more heavily granulated hairs.

That red hair is inherited is a very well-recognised fact; the exact nature of its inheritance is not, however, as yet satisfactorily determined. We have found many albino stocks with red hair and have tried to collect pedigrees of red hair. A notable one of the kind is given in Fig. 645. It is certainly not conclusively in favour of a Mendelian form of descent[1], but anyone who has examined the very considerable range of granular pigmentation in a large sample of red hairs may be excused for holding the view that they cannot all be placed in a single category. It may suffice for our present purpose to note that the chief factor in red hair as in albinism is heredity, but that red hair like albinism is not a racial character. It can appear in Australian, Chinese and Negro as well as in the European races[2], although we may find it more frequently in the Celt than in other races.

(iii) *Possible Analogies in other Mammals.* F. *Horse.* We have seen that in man macroscopic yellow and red hairs may be found that have no granular pigment, and that such types of hair may not infrequently be associated with albinos, or with minor forms of albinism. It seemed worth while investigating whether anything of a like nature occurs in other mammals. There happened to be samples of hair in the Biometric Laboratory available for this purpose. We have already seen that the

List of Chestnut Horses.

Index No.	Owners	Names	Descriptions
1	Sir Walter Gilbey	Royal Danegelt	Liver Chestnut
2	Sir Lee Knowles	Unnamed	Spotted Medium Chestnut
3	Sir Walter Gilbey	Kin-burn Sensation	Light Chestnut
4	Stansfield Collier, Esq.	Chum	Golden Chestnut
5	Messrs A. Guinness & Co.	Jeannie	Light Chestnut
6	,, ,, ,,	"Chestnut"	Golden Chestnut
7	Alfred Darby, Esq.	Ness Cattleya	Bright Liver Chestnut
8	W. R. Lysaght, Esq.	Oberon	Dark Red Chestnut
9	Royal Stud, Trakehnen	Morgenstrahl	Golden Chestnut
10	Messrs Williams & Woods	Shylock	Red Chestnut
11	A. Hall, Esq.	St Thomas	Dark Chestnut
12	Sir Gilbert Greenall	Goldfinder VI.	Black Chestnut
13	Sir Lee Knowles	Unnamed	Light Chestnut

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[1] For the small series in our Table A, we find that when one parent is red-haired, there are 11 red-haired and 13 non-red-haired offspring; when neither parent is red-haired there are 16 red-haired and 13 non-red-haired. Results not closely approaching a 1 to 1 or a 1 to 3 ratio. But here again, there may be more than one kind of red, and the red hair of a child may be dark brown in an adult so far as macroscopic appearance goes, while "black" hair appears sometimes closely associated with red, and red hairs are not infrequently found mixed with hairs of distinctly other shades. See also Appendix, p. 351.

[2] See our pp. 105, 161, 164 for evidence on this point. With selection and proper mating, it would, we believe, be possible to develop a red-haired negro or Indian "race," which might in some aspects closely resemble Scotch or Irish "red-heads": see pp. 90, 165.

Isabella horses are those which most frequently produce true albinos, and in hair from them we should expect to find the least frequency of granular pigment. No large sample of such hair being available, we turned to chestnut horses. Samples of mane, tail and body hair of a very large number of chestnut horses had been collected for another purpose in the Biometric Laboratory at University College, and 13 samples of mane and body hair were taken from these which macroscopically covered the wide range of horses classed as "chestnut." The above Table gives the present index numbers, names of owners and horses, and their general colour description as provided by the owners. Four orders were made of these samples, two for mane and two for body hairs, one of each macroscopic and one microscopic. In the former case the specimens were placed in order of intensity of colouration by aid of the eye only, the sample being in bulk. In the latter case the pigment cells were demonstrated by nitrate of silver. The work was undertaken by Miss E. Y. Thomson. Possibly another investigator might make some slight changes in the order of either series, but from an examination of the material made by one of us hardly sensible or important changes. Of course the microscopic order might receive more variation by a change of the individual hairs dealt with, but we believe the following represents fairly closely the order of colour intensity in the samples. The numerals in all columns are the index-numbers of last table.

Order of Colour Intensity in Chestnut Horse Hair Samples.

Type of Chestnut according to Body Hair		Body Hair: Microscopic Frequency of Granules		Body Hair: Macroscopic	Mane: Macroscopic	Mane: Microscopic Frequency of Granules	
Red	10	Very few	9	10	5	5	None found
Liver	1	Very few, but more than in 9	3	1	3	3	Very few
Light (gray)	13	A few, more than in 3	1	13	13	8	Good few
Light	5		13	5	8	1	Slightly more than in 8
Light	3	A good few, more than in 1 and 13	2	3	4	2	
Golden	4		10	4	9	7	Rather more than in 1 and 2
Golden ('Fuchs')	9		8	9	10	6	
Bright Liver	7	Decidedly more than in 2, 10, 8	5	7	6	4	Considerable numbers
Spotted Medium	2	More than in 5	7	2	7	9	
Golden	6	More than in 7	4	6	2	10	
Dark Red	8	Markedly more than in 4	6	8	1	11	More than in 4, 9, 10
Dark	11	Considerable number	11	11	11	13	
Black	12	Thickly studded	12	12	12	12	Thickly packed

The need of some absolute standard of pigmentation will be obvious[1]. They have been arranged here in microscopic order by comparison of slide with slide. But two or three points are obvious, namely: (i) That the judgment of intensity of pigmentation largely depends on where the hair is taken from[2]. (ii) That the microscopic and macroscopic orders can be largely different. (iii) That, as in the case of red hair in man, samples of chestnut hair can be found in the horse, which, with marked macroscopic colouring, have little or no granular pigmentation[1]. (iv) Substantial granular pigmentation comes in with the "dark" and "black" chestnuts.

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[1] Numerical appreciation would be very difficult, but they might be classified roughly, but sufficiently accurately for many purposes by a standard set of slides.

[2] The body hair was taken from the ribs. But marked differences occur according to the season when the hair is taken and the relation of the time to change of coat.

Thus horsehair seems to support the view that we have found from the rufous albino in man that macroscopic redness can be largely due to diffused pigment, and that macroscopic appearance is not a safe test of granular pigmentation, or of albinism of the hair, if we base our definition of this albinism on the absence of granular pigmentation.

G. *Dogs.* Turning to the case of dogs, Miss E. Y. Thomson has microscopically examined the hair of a number of Pekinese spaniels. This was done in relation to the albino Pekinese stock, which will be referred to in our chapter on albino animals. The point to be borne in mind is that this breed is descended from the Pekin Palace dogs through only two or three original importations. They all, therefore, connect with the same stock, and it is impossible to say, as albinos have appeared in that stock, that any are free from albinotic taint. With regard to the hair of the albino dogs themselves three points are to be noted: (α) the head, and sometimes other parts, exhibits in some of them the faintest fawn yellow. At least one of us on careful observation believes that shutting up a dog in a dark shed or exposing it in the sunlight varies the intensity of this pigmentation. It is purely non-granular and probably corresponds to the yellowing of the white hair of human albinos by exposure to the sun. This oxidation process was originally noticed by Cornaz[2]. The brilliant non-granular yellow hair mixed with the pure white of our hair samples, Nos. 81 and 82, is an illustration of the same character. (β) Under the eyes on either side of the nose, where the black mask of the non-albinotic Pekinese spaniel comes, occurs what we have termed a "spectacle mark." This spectacle mark is of a dark red colour. The spectacle marks of these dogs are in bright sunlight nearly always wet, owing to the exudation from the eyes. The opinion of one of us[3] is that the extent of the "spectacle mark" varies very considerably with the exposure of the dog to the sun, but it is not wholly due to dirt clinging to the moist hair. If hair from the spectacle mark be washed, it colours the alcohol with rather a red tinge, unlike the action of dirt, but more like that of a chemical dye. The hair left after washing has, under a low microscopic power, a marked red colour, but discloses on high power investigation no signs of granular pigment. (γ) A possibly similar phenomenon occurs with the hind-paws of our albino dog, Tong; the hairs, especially between the pads, take a reddish tinge. It does not wash off like the dirt from the remainder of the coat, and appears like a chemical staining, possibly produced by perspiration; it varies widely in amount and intensity.

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[1] We anticipated before microscopic examination, that the brilliant red of the famous Trakehnen chestnut stock,—remarkable for the fixity of the chestnut heritage—might turn out to have little or no granular pigment. This has not, however, proved to be the case.

[2] See Bibl. No. 256. Speaking of Jeane-Louise Pache and her cousin, he writes: "chez toutes deux les cheveux ont, à la fin de l'été, une teinte d'un blond-clair, tandis que les cils et les sourcils sont blancs, couleur dont se rapproche celle de la chevelure pendant l'hiver: toutes deux travaillent au grand soleil" (p. 376).

[3] C. H. Usher writes also: "Of course the spectacle mark varies very much, I thought that it must be associated with tears, purely a guess" (22/8/10).

Two of E. Nettleship's dogs have had coloured offspring, which will be discussed later; it suffices here to say that they have albinotic eyes and gray-fawn coats. The hairs of four of these dogs, Fee, Fo, Fum and Wang, have been investigated, and have been compared with the hairs of a number of other Pekinese with non-albinotic eyes, and all supposed to be quite normal dogs, although in some cases they are of albinotic descent. The following Table embodies the results reached.

Hair Analysis, Pekinese Spaniels.

Name of Dog	Age	Owners	Description of Dog	Site and Nature of Hair	Parentage
Jill (b.)	$1\frac{6}{12}$	E. Nettleship	Albino	From spectacle mark, dark red: no granules	♂ red × ♀ red and white
Fee (d.)	$\frac{2}{12}$	E. Nettleship	Incomplete albino (gray-fawn)	From back, gray-fawn: no granules	albino × albino
Fum (d.)	$\frac{5}{12}$	E. Nettleship	Incomplete albino (gray-fawn)	From back, darker gray-fawn: no granules	albino × albino
Wang (d.)	$1\frac{6}{12}$	Mrs Johnson	Incomplete albino (ash-brown)	From lightest to darkest hairs: no granules	albino (Jill) × albino (Jack)
Fo (d.)	1	Mrs J. S. Leake	Incomplete albino (fawn to ash-fawn)	"Arm-pit," slight creamy diffused pigment: vacuoles but no granules; front of neck no diffused pigment: vacuoles but no granules	ditto × ditto
— ? (d.)	1	Mrs Franklin	Normal (red, black mask)	From back, "red": no granules	♂ dark red × ♀ red
Little Oo (d.)	$\frac{9}{12}$	Mrs Dew Smith	Normal (fawn, black points)	From back, "fawn": no granules to be found in body of hair: one or two were discovered at the tip. Black hair from tail: thickly packed with granules	♂ bright red, black mask × ♀ "biscuit"
Exning Huli (d.)	$1\frac{9}{12}$	Mrs Dew Smith	Normal (red, black points)	In the body of the red hair no granules found, but the tip, which is much darker, contains a considerable number; black hairs extremely thick in granules	
Chinchilla (b.)	$\frac{2}{12}$	Mrs Franklin	Normal (mixture of lightest fawn and black hairs)	Fawn hairs have no pigment granules; black hairs, many and often crowded granules[1]	♂ red brindle (no white) × ♀ albino
— ? (b.)	$\frac{8}{12}$	Mrs Franklin	Normal (sable, black mask)	Sable part of hair has no granules; black hairs loaded with them	♂ red brindle (no white) × ♀ black & tan
Minoru (d.)	$1\frac{4}{12}$	Mrs Franklin	Normal (red, black mask)	Three shades are found in single hairs, fawn, red, black. The fawn shows no granules at all; in the red part of the hair very fine granules, but not nearly so thick as in black part which is crowded[2]	♂ red brindle (no white) × ♀ golden red
Gollywog (d.)	$2\frac{3}{12}$	Mrs Mark Mayhew	Normal (nearly black)	Body dark red-black. Tail black, both densely studded with fine granules	♂ albino × ♀ black
Prince Kung (d.)	$3\frac{4}{12}$	Lady Lovelace	Normal (red, some white, black points)	Red hairs, bright yellow diffused pigment, with a decided number of distinct brown granules, the white hairs have no granules, and the black hairs are thickly crowded	♂ red brindle × ♀ red

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[1] Some hairs of Chinchilla were like those of Minoru, combining fawn lower half, black upper half, the tip being most crowded with granules.

[2] Starting along the hair, at first no granules are seen, then working along the hair granules gradually appear on one side of the core; getting near the black part granules are seen on both sides of the core, and really in the black part the granules are very thick.

Now it will be seen from a study of the above Table that if we except the black hairs, chiefly those of the black "points," although they are sometimes mixed with the light-coloured hairs, the body colour of the Pekinese—whether fawn, sable, red, or the gray-fawn, which is almost the Isabella of the horse or the "lilac" of the fancy mouse—is practically produced by diffused pigment[1]. Thus the differentiation in the coat—black hairs excepted—between the normal and albino Pekinese is not one of granular pigmentation. From our standpoint the main fact of interest is that this red-fawn-sable breed of dogs, which is already markedly albinotic as far as the coat is concerned, is the one which has produced in so marked a manner albinos. It serves again to emphasise the reality of the link between the xanthous, the rufous and the completely albinotic, which must have impressed the reader not only of this chapter, but of our earlier accounts of dark race albinos. One of the most interesting correspondences is the occurrence in the same individual of hairs of different colours, some crowded with granules and some wholly without them, precisely as we have found in the case of certain Papuan albinos: see Nos. 20 and 70. Indeed, the occurrence of isolated dark hairs, or even tufts of hair, in the snow-white hair of albinos, seems to find an analogy in the black hairs occurring in the fawn or sable coats of these Pekinese.

H. *Mice.* The results for the coat hair of the Pekinese spaniels are closely confirmed by the microscopic examination of the hairs of Japanese waltzing mice. As is well known, these piebald mice are clinically completely albinotic as far as the eye is concerned. The coat hair is white, except for patches of colour which vary from somewhat pale yellow through fawn to almost red. A random sample of seven of

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[1] In addition we were able to obtain hair from the mother and sister of an albino puppy closely allied to our own stock.

Name of Dog	Owner	Description of Dog	Nature of Hair	Parentage
? (b.)	Mrs Perkins	Normal. Mother of albino	Body light fawn, occasional darker hairs. Lighter hairs, no diffused pigment, no granules. Darker hairs, very dark brown pigment, densely packed granules (ζ)	Normal ♂ × Normal ♀
? (b.)	Mrs Perkins	Normal. Sister to albino	Body red fawn. Lighter hairs, no diffused pigment, one or two granules (α); darker hairs, bright yellow diffused pigment, plenty of small granules (δ)	Normal ♂ × Normal ♀

We have tried one or two dogs of other races. Thus a bull-dog with a mixture of two kinds of hair. The black variety had a brown diffused pigment and was densely packed with granules (ζ); the red variety with a white tip was very complex. Starting from the tip, there was a very slight pale yellow diffused pigment, and a suspicion of small granules, but not distinct; gradually travelling along the hair to the red end, the diffused pigment becomes deeper and deeper yellow and the granules more and more distinct, until they reach very plentiful (ϵ), but they are always small. A Yorkshire terrier with red hair showed pale yellow-brown diffused pigment and a decided number of granules scattered throughout the hairs (γ).

these mice was procured; two, (*a*) and (*b*), were of the light fawn class; three were fawn, (*c*), (*d*) and (*e*); while two, (*f*) and (*g*), showed to the naked eye a dusky hue in the fawn, and on examination with a lens the hairs were at once seen to be of two kinds, the usual fawn colour and a darker hair, a mixture corresponding closely to that of several of the normal Pekinese spaniels we have examined. The mice were procured in the open market, and we cannot be certain whether they were pure bred; they were waltzers and had completely albinotic eyes. Of these mice the hair samples in (*a*), (*b*), (*c*), (*d*) and (*e*) showed under low power diffused pigment, in (*a*), (*b*) and (*d*) of a pale yellow, and in (*c*) and (*e*) of a darker shade. Under a high power there were no granules in the hairs of (*a*), (*b*), (*c*), (*d*) and (*e*). In the case of (*f*) and (*g*) the light hairs showed diffused pigment and no granules. In (*f*) there were granules present in hairs of the darker type, and in (*g*) some scattered granules in some of the second type hairs. It will be seen how closely this corresponds to the coats of the Pekinese dogs. If albinism of the hair be defined as absence of granular pigment, then certain of the Japanese mice are complete albinos and others are incomplete albinos as regards the coat. If albinism be defined as the absence of any pigment diffused or granular in the coat, then the Japanese mice are all incomplete albinos, but so are many human albinos, who have diffused pigment in the hair and no granular pigment. The difficulty, then, as to classification of the albino becomes very great, for the same hair may at one time show diffused and at another time no diffused pigment, while a part of the head may have white and a part quite yellow hair (Thèrese Rey, No. 81). It follows that, if we take the absence of granular pigment to be the mark of albinism, then a large number of Japanese mice must be looked upon, like the piebald or whole colour offspring of the albino Pekinese, as complete albinos. This makes it of very great interest to follow up what happens when such Japanese mice are crossed with completely albinotic white mice. It is well known that the result is always a dark-eyed mouse with a good deal of colour in the coat. This hybrid has been stated to be in coat colour like the ordinary gray or wild mouse—a statement quite incompatible with an examination of the coats of a large number of these hybrids. Until dissections have been made of the eyes it is impossible to say whether or no these eyes vary from normally pigmented eyes; they may well have, as the coats, a variation in pigmentation greater than that of the normal wild mouse, if less than what occurs in the offspring of the hybrids crossed among themselves. That the eye of the offspring of two mice with completely albinotic eyes should be pigmented has never been explained, except by the vague reference to the fact that one mouse had "some colour in the coat." If this coat, however, had no granular pigment, then the difficulty of such vague explanations becomes still greater. In order to consider the nature of the hair in the hybrids from white mice and Japanese waltzing mice, samples were taken from the middle of the back of the coats of eight hybrids in the collection of the skins made by the late Professor Weldon. The skins were selected to cover as wide a range of variation as possible. The results were as follows:

Mouse	Index No.	Weldon's Classification	Colour Scale[1]	Nature of Hair
Wild gray	h	—	—	Granules, in the darker hairs densely packed
Hybrid	i	Yellow	No. 35. *95*	Diffused pigment; some hairs darker than others, no granules
,,	j	Yellow to fawn-yellow	No. 37. *55*	Some diffused pigment; no granules
,,	k	Yellow to fawn-yellow	No. 37. *35*	Diffused pigment; no granules
,,	l	Yellow	No. 33. *100 z*	Some diffused pigment; no granules
,,	m	Pale wild colour	No. 49. *55*	In some hairs hardly any diffused pigment, in some quite a lot. Granules in the darker hairs in small quantity
,,	n	Chocolate to pale wild colour	No. 49. *45*	Diffused pigment; granules in some of the hairs in fair quantity. Some of the hairs no diffused pigment and no granules
,,	o	Black	No. 57. *100 x*	Diffused pigment; granules in fair quantity
,,	p	Pale wild colour	No. 52. *45*	Diffused pigment; granules in fair quantity
,,	q	Pale wild colour	No. 49. *35*	Diffused pigment; granules fairly numerous in some hairs

It will be seen at once from these results that the hybrids can only be superficially described as like the wild mouse; so far as the hair is concerned they exhibit a wide range of granular pigmentation. Some have no granules at all, and might be classed as albinos of the coat, others have some hairs albinotic and others with granular pigment, while again some have fair quantities of granules—generally many less than those of the wild mouse—in all the hairs examined. How far the mice without granular pigment arose from the Japanese mice without granular pigment, it is now impossible to say[2], or again how far there may have been Japanese mice like (*f*) and (*g*) above with *some* hairs showing granular pigment. But, since in all cases the eyes macroscopically were dark, the complete absence of granular pigment in the parents is compatible with the appearance of granular pigment in the offspring. From this standpoint the question of whether granular pigment can appear in the offspring of albinotic Pekinese dogs with only diffused pigment of the coat becomes of first class importance.

Thus far, however, it does not seem as if there were any essential differences between albinism in man and the lower mammals. Not only in the eye, but in the hair, albinism is not a simple character but a very complex one, possessing apparently a wide range of variation. It may be that we shall ultimately have to divide albinos into two classes: (i) a class which can produce pigment in a diffused state, but no granular pigment, (ii) a class which is capable of producing granules (and ? does produce vacuoles), and would produce them if there were any pigment to store in them. The value of such a classification would depend on the identification chemically of the diffused and the granular pigment (see footnote, p. 349). Such a double nature in albinos would enable us to some extent to account for the appearance of granular pigment in the offspring of two parents, neither of whom had granular pigment. One parent would belong to class (i) and the other to class (ii). On the other hand, the above series of hairs from the hybrids of white mice and Japanese mice seems to show that either class must form a graduated scale in the intensity of pigment production. Otherwise we should hardly be able to throw light on why a Japanese mouse without granular pigment can give with a white albino mouse offspring granularly pigmented as far as the eyes are concerned, but two Japanese mice with granular pigment do not produce non-albinotic eyes in their offspring. On the whole it is better not to manufacture at present any hypotheses, but content ourselves by saying that, as far as the hair is concerned, albinism is not a simple unit character, but one of great complexity, and almost certainly pointing to one, if not two, graduated variates, *i.e.* frequency of granules (with, possibly, frequency of vacuoles) and amount of diffused pigment, and that these variates conceivably may define two different types of albinism.

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[1] The first number is the shade on the glass mosaic scale of the Biometric Laboratory, the second the percentage of coloured parts of the skin to the whole. Thus only two mice were whole coloured and of these "o" had a distinctly lighter belly colour; the remainder were piebalds.

[2] The skins of the original Japanese parents were unfortunately not preserved.

I. *Hair of Animals reputed Albinos.* Owing to the courtesy of the Hon. Lionel Rothschild Dr Ernst Hartert kindly forwarded to us samples of the hair of the following albinos in the collection at Tring for microscopic examination.

(i) *Sooty Phalanger.* Trichosurus vulpecula fulginosa (Tasmania). Pink eyes. Hair: macroscopic, fawn-red; microscopic, no granules, very pale yellow-green diffused pigment.

(ii) *Common Hare.* Red eyes. Hair: macroscopic, white and red; microscopic, very plentiful (δ) and very minute granules in some of the hairs, very pale greenish-yellow diffused pigment.

(iii) *Sable.* Martes zibellina. No particulars as to eyes known. Hair: macroscopic, pale buff; microscopic, no granules.

(iv) *Sable.* Martes zibellina (Siberia). Eyes paler than normal in mounted specimen. Hair: macroscopic, cinnamon-gray in appearance; mixture of white and dark hairs; microscopic, granules plentiful in some hairs (δ), very pale browny-green diffused pigment.

(v) *Urson.* Erethizon dorsatum (Canada). Eyes red. No pigment granules found in spines.

(vi) *Badger.* Meles taxus (Warren, Folkestone). Eyes pink. Hair: macroscopic, pale grayish-white; microscopic, no granules and no diffused pigment.

(vii) *Chacma-Baboon.* Cynocephalus porcarius (Transvaal). Eyes pink. Hair: macroscopic, pale gray-white; microscopic, no granules and no diffused pigment.

(viii) *Hamster.* Cricetus frumentarius (Germany, from the collection of the Brothers Wiebke). No record of the eyes. Hair: macroscopic, pale buff; microscopic, no granules and extremely pale diffused pigment.

(ix) *Racoon.* Procyon lotor (N. America). Eyes pink. Hair: macroscopic yellowish-buff; microscopic, no granules and scarcely any diffused pigment.

(x) *Bennett's Kangaroo.* Macropus ruficollis bennetti (Tasmania). Eyes pink. Lived several years in the London Aquarium. Hair: macroscopic, palest buff tinge; microscopic, some granules in a few parts of the hair (β) and extremely pale diffused pigment in parts.

It will be seen that these results are very similar to those we have found in the case of man and dog. Seven out of the ten (including the Urson) are completely albinotic, *i.e.* without pigment granules so far as the coat is concerned. Of these seven all but the sable (iii) and the hamster (viii), both *without record*, are reported to have had albinotic eyes. On the other hand the macroscopic appearance of their hair may be pale buff to fawn-red; pure white is not an essential condition of albinism, although it is very nearly reached in the case of the badger and the baboon. Of the three animals that show pigment granules, or incomplete albinism of the hair, the eyes of the sable (iv) with a cinnamon-gray coat are only said to be paler than normal, the hare and the kangaroo are reported to have had albinotic eyes; the hare had plenty of red in the coat, but the kangaroo only the palest buff tinge, both show granules; the hare plenty of minute granules and the kangaroo some granules in a few parts of the hair.

Of course it may be said that a microscopic examination of the eyes might have shown incomplete albinism there also, but it is conceivable, on the other hand, that some granules might be found in the hairs of the other seven albinos (the hair samples of which were found to have no granules), if the whole coat had been overhauled microscopically[1]. It seems fairly clear that graduations in the extent of albinism are as frequent in the lower animals as in man.

J. *Conclusions.* The material we have brought together in this chapter, though possibly more extensive than has yet been summarised from the standpoint of albinism of the hair, is admittedly inadequate and rather suggestive for further lines of inquiry than conclusive on any one point. But it will, we think, indicate that the exact definition of albinism of the hair is by no means obvious, and that before we can be clear on this matter far more elaborate studies of granular pigmentation and diffused cellular pigmentation of the hair of man and other animals, especially in relation to heredity, are requisite. As a matter of fact we do not at the present know whether these two pigments are alike either in chemical constitution[2] or in their metabolic

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[1] One of our albino puppies, offspring of two albinos—E. Nettleship's "Patty"—showed a few minute granules in the hairs of a part of her tail when 3 to 4 weeks old. A search at 3 to 4 months failed to reveal any granules at all. Colour was then visible in her coat though less markedly; since that date she has become whiter than her parents.

[2] Spiegler (*Beiträge z. chem. Physiol. u. Pathol.* Bd. IV. S. 40, 1904) obtained, what he has termed "white melanins" from white sheep's wool and white horsehair. He considers that these are identical "im Kerne" with melanins of black wool and black horse-hair. He gives the formulae:

Melanin		*"White" Melanin*	
Black Horsehair	Black Wool	White Horsehair	White Wool
$C_{50}\ H_{58}\ N_8\ SO_{12}$	$C_{46}\ H_{68}\ N_8\ SO_{20}$	$C_{45}\ H_{78}\ N_{10}\ SO_{20}$	$C_{61}\ H_{98}\ N_{10}\ SO_{20}$

The divergencies between these formulae are hardly greater than those found for different kinds of black melanin or for the same kinds provided by different authorities, hence arises the view of Spiegler that the differences are not really fundamental. This view has been criticised by Gortner (*American Naturalist,* origin. If they are alike in both, is it merely a structural difference of tissue which renders the diffused pigment common, the granular pigment rare, in albinos? The two pigmentations can hardly be independent, for stocks in which the diffused pigmentation only appears, or is the more important factor of the whole hair pigmentation, seem to be those in which complete albinism is especially likely to arise; and, conversely, stocks in which complete albinos have occurred are those in which coloured but non-granular pigmented hair will frequently be found.

The Pekinese spaniels form a race in which we find, in cases without any macroscopically recognisable ocular albinism, individuals with all their hairs studded with pigment granules, others with parts of the same hairs so studded, again others with separate hairs with and without granular pigment, and finally others in which the body hair is without granular pigment at all. In this race appear albinos with apparently a *clinically* complete ocular albinism. How far this process is a reversible one we have yet to learn. Will the incomplete albinos with markedly coloured coats—still coats without granular pigmentation—ultimately produce descendants with granular pigmentation? That is a question for the future, but for the heredity of albinism it is an important question.

Nor regarding even the imperfect material of the present chapter can one overlook two other important points which emerge. The first is the very wide range of incomplete albinism of the hair; it is practically as wide as the already recognised range of incomplete ocular albinism. It is sufficient to show how difficult any rigid definition of albinism must be in practice. The second point is the relatively slight link there appears to be between albinism of the eye and of the hair in many of these incomplete cases, and possibly in some of the complete cases. It is probable that further progress in our knowledge of the differences between the two fundamental pigment types in hair will come rather from chemical than from further microscopic research. But these chemical inquiries ought certainly to differentiate the classes of hair dealt with not only by their macroscopic appearance, but also by the microscopic test of the presence or absence of granular pigmentation.

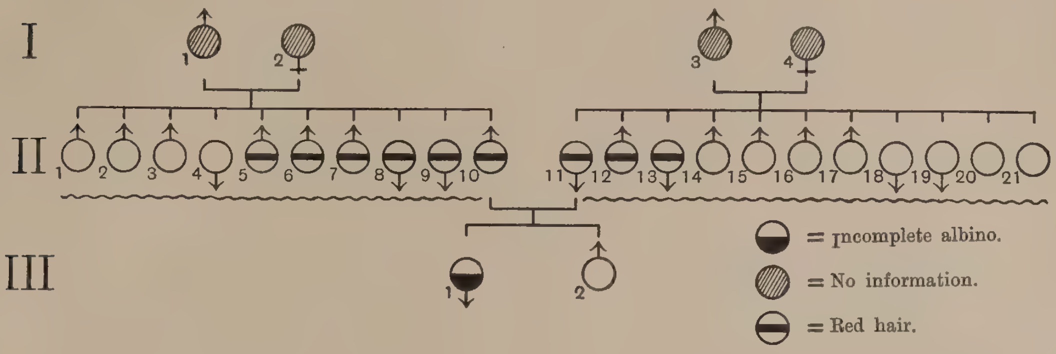
Vol. XLIV. pp. 497—502, 1910) who holds "that the proportions are so widely different that no close relationship seems possible." This author obtained from black wool 1·84 °/₀ of black melanin, and from white wool only 0·06 °/₀ of a grayish-brown body by an exactly similar method. Coupling these facts together (he does not give the chemical constitution of either of his products) he concludes that "Spiegler's 'white melanin' is not a substance belonging to the melanin class, but is a product from the keratin by the action of alkalies," and further that it bears no relation to true melanins. The relative difference in quantity hardly seems a convincing argument, and probably most readers will at present be content to leave the matter as left by Spiegler himself in a passage cited by Gortner himself from Spiegler's memoir of 1907 (*Beiträge z. chem. Physiol. u. Pathol.* Bd. x. S. 253, 1907):

> "These questions need a more searching study. We must now determine whether albino hair gives the same oxidation products as pigmented hair. It is in this manner that we can finally decide whether the colour of gray hair is due, as we have previously supposed, to disappearance of pigment and to air content or rather to the change of the darker pigment into lighter ones."

So far there appears no marked microscopic differences in senile gray, leucodermatous and albinotic hair, except the occasional appearance in the latter of the non-granular diffused yellow or red colouring, and possibly, but not certainly, somewhat fewer vacuoles.

APPENDIX. Chapter VIII (see footnote, p. 315). While this chapter was in type Dr Rudolf Galloway of Aberdeen has sent us a most interesting case showing the association of red hair and albinism.

The pedigree is as follows:



Concerning the grandparents I. 1, 2, 3 and 4, we have no information. J. H. the father, II. 10, is a labourer, aged 37; he was seen by Dr Galloway breaking stones by the roadside. His hair is a bright red. Microscopically examined this hair shows pale yellow brown (going in parts to almost white) diffused pigment; there is a decided number of minute granules. Eyes: pale blue, no visible anterior iris pigment. Vision evidently good, but not tested. II. 5, his brother, has very pale red hair almost as light as that of the incomplete albino, III. 1, his niece. II. 6, 7, 8 and 9 have all red hair. II. 1, 2, 3 and 4 have fair to light brown hair. The whole family II. 1 to 10 have light coloured or bluish eyes. E. H., born E. F., the mother, II. 11, is aged 33. Her hair is macroscopically dark red, a dark chestnut brown; before the age of 17, it is said that it was very much fairer. Eyes, pale blue, no visible anterior iris pigment. Vision: R. $\frac{6}{12}$, Hm. 0·5 D. cyl. axis vert. $=\frac{6}{6}$ several letters. L. $\frac{6}{9}$ Hm. 0·5 D. sph. $=\frac{6}{6}$ 1 or 2 letters; reads Jaeger 1 well. Fundus: somewhat pale, but shows uniform normal pigment mottling. Of her siblings: II. 12 has red hair and brown eyes; II. 13 (now dead) had red hair and brown eyes; II. 14 and 15 have fair hair and light, probably bluish eyes; II. 16 and 17 have very dark hair and eyes; II. 18 and 19 brown hair and brown eyes, while II. 20 and 21, sex unrecorded, have medium to dark hair, and light, probably blue eyes. Those members of the family who originally had fair hair have all grown darker haired with age.

N. H. aged 12, the incomplete albino III. 1, is a well developed intelligent girl, clever at school. She suffers from bright light causing headache. No abnormality of pigmentation noticed in the skin of any part of the body, but photograph shows typical albinotic appearance. Hair: macroscopically pale flaxen, eyebrows slightly darker. Microscopically there is no diffused pigment, and there are no granules. N. H. is thus, as regards the hair, completely albinotic. Eyes: pale blue, no visible anterior iris pigment. Vision: R. $\frac{6}{18}$, Hm. 0·5 D. sph. $=\frac{6}{12}$; L. $\frac{6}{24}$, Hm. 0·5 D. cyl. axis vert. $=\frac{6}{18}$; reads Jaeger 1. Fundus: albinotic, the choroidal interspaces being paler than the choroidal vessels. No nystagmus. Her brother, III. 2, aged 10, is a well grown, intelligent lad. Hair, light ash or gray brown, no trace of red. Microscopically there is a very pale watery brown diffused pigment, and plenty of small granules. Eyes: pale blue, no visible anterior iris pigment. Vision: apparently good; refraction almost normal, slightly hypermetropic. Fundus: fairish, but uniformly pigmented.

This family serves to emphasise (i) the association of albinism with red-haired stocks and (ii) the fact already indicated in our Fig. 645 (see also p. 341) that any type of red hair mated with any other type of red hair will not in man produce invariably red-haired offspring. A light red and a dark red may have albinotic and light brown haired children.

CHAPTER IX.

THE ALBINOTIC EYE (LOWER ANIMALS).

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Section I. *Introductory.*

The present Chapter has been undertaken as part of our monograph on albinism in man for two reasons: first, because the opportunities for dissection and microscopic examination of the several types of human albinotic eye must necessarily be very infrequent, and there are many points—especially those bearing on the characteristics of the eye in dark skinned races—which may probably be elucidated by an examination of the albinotic eye in the lower animals. Secondly, because we have not found any very complete treatment of the albinotic eye in the lower animals. While it has been pressed upon us in the course of our investigations that the eye of the human albino varied widely in its degree of pigmentation from race to race and also within the race, biological writers on albinism in the lower mammals seem to have assumed that the albinotic eye in these cases was a structure unique in character and admitting of no graduations in pigmentation. This was the conclusion reached by the early writers, and appears to have remained for a long time unquestioned. Duddell[1] (1736) makes this statement, very possibly correct, with regard to the choroids of

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[1] See Bibl. No. 55.

"white Rabbits' Eyes" of which he dissected several. Lecat[1] (1765) repeated Duddell's observation and also pointed out the absence of choroidal pigmentation in the eye of the white rabbit. Buzzi[2] (1784) made a much more extended investigation of the choroid and iris of the white rabbit, but the chief aim of his investigation was to demonstrate by depriving the ocular structure of all blood that the red appearance of the eye was due to the blood. De Saussure[3] (1779) knew of the white iris, red pupil and absence (?) of the uvea in the white rabbit.

A wider view was taken by Seiler[4] in 1833. He had observed imperfect albinism of the eye in two girls, Marie Gehler, aged 14, and Wilhelmine Steude. Their pupils were violet with some want of blackness, irides light gray blue, there were myopia, nystagmus and photophobia, the skin whiter than normal, and hair yellow white, almost as in albinos, tending to red in Steude. Such cases opened his eyes to incomplete albinism in animals. He recognised that the white horse with black pupil and brown iris is not the most frequent source of albinotic variations in the equine race[5]. Seiler points out that the Isabella horse is an incomplete albino. The hair is the light yellow reddish Isabel colour. The mane and tail are yellowish white or light brownish. A darker stripe runs at times along the backbone. The iris is white to the edge of the pupil which has a very thin black frame-like border. The pupils appear black. Seiler dissected several eyes of such horses and found the choroid to corpus ciliare, and the iris as far as the above mentioned border as well as the corpora nigra without black pigmentation. Seiler tells us that Isabella horses occur without the dark stripe on the back, with reddish pupils and white irides without the black border. These are true albinos and termed *Hermeline* to distinguish them from other Isabella horses. Seiler had seen three cases in the Royal Stables at Dresden, and an old groom told him that formerly there had been more horses with red pupils. This association of incomplete and complete albinism is not without interest for man and albinism in other mammals, and the general problem of the "rufous albino" has been discussed in the previous chapter.

A direct attempt has been made for some centuries in Denmark to breed a race of horses with pigmentless skins, white coats and white irides (*glas-øiet*). But these horses seem to be associated with great infertility, and new blood has had to be introduced from the grays or from Isabella stocks. It is possible to combine dark nut-brown eyes with a completely pigmentless skin, but to preserve the "glass eyes," which are supposed to be characteristic of the race, is extremely difficult, and individuals with these eyes are often cross-bred and have not the pure white skin. Some of this white stock from Frederiksborg were transferred to Hannover, but we are told that the same want of fruitfulness occurred there, and that horses bred there and returned to Frederiksborg did not show the red transparent ears of the true stock. The whole question of the breeding of these albino and semi-albino horses is a most interesting one, especially with regard to the difficulty of associating completely albinotic eye and skin, but to discuss it would carry us beyond the limits of this chapter[1].

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[1] See Bibl. No. 67, p. 106.

[2] See Bibl. No. 95. When strangled the albino rabbit retained its "red eyes" for some time after death, decapitated it lost them as the blood passed away; starved to death, it lost them also. The experiments are characteristically crude, not to say cruel.

[3] See Bibl. No. 88.

[4] See Bibl. No. 201.

[5] Rudolphi in 1828 reported that he had seen a white horse with half the iris white and half dark (see Bibl. No. 187), and Seiler states that white horses with truly albinotic eyes really do occur. The exposed skin of the white horse is usually pigmented as well as the eyes.

In contradistinction to Buzzi's observation on the human albinotic eye, Seiler found the "uvea" always present in dissecting the eyes of Isabella horses, and as already noted the presence of the pigment carrying membrane[2], in the absence of the pigment, has been confirmed by Wharton Jones (1833) and Manz (1878): see our pp. 167, 270—71.

Beyond the above early investigations apparently little has been done with the complete and incomplete albinotic eye of the lower animals[3]. In 1900 the late Professor W. F. R. Weldon drew the attention of K. Pearson to the variation of the amount of pigment in the eyes of mice and to the difficulty of classifying mice under the two categories of albino eyed and normal eyed. It was this knowledge of the existence of dark ruby eyed albinos, which suggested some of the following investigations.

The observations which we provide are recorded as contributions to the subject, rather than as an exhaustive treatment, to which they lay no claim. In particular it will be seen that attention has been directed much more to the presence or absence of pigment than to its exact nature or colour. No attempt has been made to distinguish between pigments of different colours,—if indeed there be any intrinsic difference of this kind. Only in certain cases of subnormal colouring the pigment is noted as light brown or lighter than the usual tint. On the other hand careful attention has been given, both by Mr Coats and C. H. Usher, to the varieties of degree and of distribution in the albinism of the two fundamental pigmentary structures of the eye, the mesoblastic (stroma) and epiblastic retinal epithelium of the uveal tract. From the descriptions and conclusions that follow it will be seen that whilst in some of these animals a condition is found exactly comparable to the pale blue blond eye in man, viz. absence of stroma (mesoblastic) pigment without visible deficiency of epithelial (epiblastic) pigment, in other specimens there is deficiency of the latter also; and that when these defects of pigmentation affect portions of the uveal tract —a piebald condition of the iris or of the choroid—both layers (mesoblastic and epiblastic) or only one may be involved, so that, as Mr Coats puts it, every conceivable combination both in topographical arrangement and degree of deficiency of pigment may be met with: and lastly, that in mice, at any rate, it is sometimes impossible to tell without microscopical examination whether the specimen is completely albinotic or contains a little pigment. In regard to the colour of the iris as seen during life in the imperfectly albinotic eyes, the present observations confirm in an interesting manner our previous knowledge that when the mesoblastic pigment is absent the iris is either white (the so-called "wall" eye) or blue or slaty blue according to its thickness and texture, a thick and fibrous iris being white and opaque throughout or translucent only at its thinnest part[1]. In the horse even the thinnest or pupillary zone is probably too thick to be translucent. The region of greatest thickness of the iris differs in different species; in man and several of the mouse order it is close to the pupil, in the horse near the periphery.

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[1] See especially V. Prosch: *Frederiksborg-Stutteri*, S. 20 *et seq.*, Kjøbenhavn, 1866.

[2] Buzzi is a little obscure, but it appears to be the "existenza della membrana" rather than the absence of the pigment on which he is insisting, and later writers have at any rate so interpreted him. In particular Wharton Jones first laid great stress on the presence of the membrane without the pigment.

[3] There have been endless records, for example, of albino birds often based merely on white feathering; but as far as we are aware no attempt has been hitherto made to study how far their eyes were non-albinotic, completely or incompletely albinotic; a point requiring more than the mere statement, itself often omitted, that the eyes were "red" or "black."

An apparent discrepancy is sometimes noticed in the colour of the choroid of incompletely albinotic eyes as seen by ophthalmoscopic examination of the living and macroscopic inspection of the same eye opened after death; the intervascular spaces which were "white" to the ophthalmoscope being pigmented to a visible degree in the dead specimen. The full or empty condition of the large choroidal vessels doubtless accounts in part for this, and the different degree and colour of the illuminant must also be taken into account.

A description has been added of the clinical appearances and family history of an almost completely albinotic horse examined by E. Nettleship in 1907. We have hitherto not succeeded in meeting with a perfect albino horse; the epiblastic pigment of the iris seems peculiarly persistent.

We also include accounts by C. H. Usher of the eyes of a number of completely and incompletely albinotic birds.

SECTION II. *Partial Albinism in the Eye of the Dog.*

A. *Normal and "Wall" Eyes.*

By GEORGE COATS, M.D., Assistant Surgeon, formerly Curator to the Royal London (Moorfields) Ophthalmic Hospital.

The following remarks are founded on the examination of four pairs of eyes submitted to me by E. Nettleship.

Normal Distribution of Pigment in the Eye of the Dog. In the distribution of its pigment the eye of the dog differs from that of man in certain particulars. At the sclero-corneal margin pigmented cells occur among the deeper layers of the sclera, and in the layer immediately anterior to the membrane of Descemet they often penetrate into the cornea for some distance. The trabeculae of the ligamentum pectinatum are pigmented in places. A slight degree of pigmentation in all these situations may often be found in the human eye, even in lightly pigmented specimens.

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[1] In three albino dogs I have found that only the pupillary zone of the iris is translucent to ophthalmoscopic illumination, this part being in the dog (and we may add, in the horse also) the thinnest region of the iris; the remainder is thick enough and dense enough to be opaque. E. N.

In the uveal tract of the dog the pigment epithelium presents no special features. In the stroma of the iris and ciliary body pigmented cells are of two kinds: (1) Chromatophores; (2) Clump cells (*Klumpenzellen*).

(1) The chromatophores are irregular branched corpuscles similar to those of the human eye. On the anterior surface of the iris there is a thin pigmented layer, formed of closely packed chromatophores. It is more sharply defined than the similar layer in the human iris. Immediately beneath this the pigmentation is not so dense, but in the posterior half of the iris the chromatophores are aggregated into a close interlacing network, which greatly obscures the structure of the part. Chromatophores are absent immediately anterior to the pigment epithelium, in a thin layer which contains the dilatator pupillae—a well defined structure in the dog. The dilatator, and also the sphincter, contain scattered pigment granules, which resemble those of the pigment epithelium.

(2) The clump cells also correspond to corpuscles found in the human eye. They do not show the branched, irregular form of the chromatophores, but are rounded and more densely crowded with pigment. The pigment is coarser. Their number is small and in deeply pigmented eyes they are not always easily distinguished, being swamped by the chromatophores. In the human eye these cells were first mentioned by Koganeï[1] and have recently been described in detail by Elschnig and Lauber[2]. They occur here and there throughout the iris, but especially in certain groups associated with ingrowths of the pigment epithelium, viz. (1) At the sphincter border in connection with the termination of the pigment epithelium (ingrowth, or spur, of Elschnig and Lauber). (2) About midway in the breadth of the sphincter (Fuchs' spur). (3) At the peripheral border of the sphincter (v. Michel's spur). These last two spurs are associated with groups of muscle fibres running from the dilatator to the sphincter. (4) At the junction between the iris and the ciliary body (Grunert's spur). This group is associated with the terminal fibres of the dilatator.

All these spurs are represented in the present series of eyes, except perhaps that of Elschnig and Lauber, and in addition large numbers of clump cells are found in the ciliary body. They are mostly in the inner layers, but extend also among the fibres of the ciliary muscle. They are especially abundant in the pars plana, and may reach well towards its outer surface. It is unusual to find them in this situation in the human eye. I have been unable to find them in the choroid.

While the chromatophores are derived from the mesoblast, clump cells, according to Elschnig and Lauber, are derived from the pigment epithelium. The grounds for this assumption are as follows: (1) Embryologically they are developed in association with the pigment epithelium, at a time long anterior to the first appearance of the stroma pigment[3]. (2) They are most numerous near the pigment epithelium and where spurs of it project into the iris; in some cases they have a direct connection with such spurs. (3) They frequently occur in association with bundles of muscle fibres passing from the dilatator to the sphincter, and according to a widely accepted view both the dilatator and the sphincter are derived from the pigment epithelium. The dilatator itself, and in some cases the sphincter also, may be strewn with pigment similar to that found in clump cells. (4) In appearance and histochemical reactions they differ from the chromatophores, and resemble the pigment epithelium. Chromatophores are branched, clump cells unbranched. The pigment in clump cells is much coarser, and exactly resembles the pigment of the pigment epithelium. Clump cells resist depigmentation much more energetically; they have also a greater resistance to decolorisation when stained by thionin, or by the Weigert-Pal method. In all these respects they are affiliated to the pigment epithelium. When depigmented the nucleus resembles that of the pigment epithelium. (5) In various pathological conditions, especially iritis and chronic glaucoma, the clump cells proliferate and wander into the iris stroma. This is analogous to the wandering of the pigment epithelium into the retina in cases of choroido-retinitis, etc. (6) In the eye of a partially albinotic cat Lauber found complete absence of the stroma pigment with preservation of the clump cells and the pigment epithelium. This is evidence of the identical origin of the last two. It will be seen presently that this observation receives confirmation in the present series of cases.

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[1] *Arch. f. mikr. Anat.* Bd. xxv. S. 1, 1885.

[2] *Arch. f. Ophth.* Bd. LXV. S. 428, 1907.

[3] Lauber, H., *Arch. f. Ophth.* Bd. LXVIII. Heft 1, S. 1, 1908.

Clump cells are said to be equally numerous in blue and in brown irides, being in either case too few in number to modify the prevailing tint produced by the chromatophores. By their aggregation they are believed to give rise to some at least of the mole-like spots often observed on the iris, and to the melanomata and malignant tumours which may originate from them[1].

In addition to clump cells, chromatophores of the ordinary type occur in the ciliary body of the dog. They map out the fibrous tissue between the bundles of the ciliary muscle in much the same way as in the negroid races of man. In the choroidal stroma the pigmentation is very dense, and seems to be due entirely to chromatophores, clumps cells being absent. The pigment epithelium loses its pigment over the tapetum. As compared with the human eye the choroid takes a much larger share in forming the lamina cribrosa in the dog, and the trabeculae which it contributes are usually pigmented.

The pigmentation of the sclera at the corneo-scleral margin has already been mentioned. Further back there are a few chromatophores, usually in the deepest layers. In the scleral promontory at the edge of the nerve entrance pigmentation again becomes dense. The trabeculae contributed by the sclera to the lamina cribrosa are sometimes slightly pigmented close to the scleral promontory, but much less so than the corresponding trabeculae of the choroid.

The conjunctival epithelium, especially in its deepest layers and near the limbus, is frequently pigmented. A few branched pigmented cells may be present in the underlying conjunctiva and sclera.

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[1] Fuchs, *Arch. f. Augenh.* Bd. XI. S. 435, 1882; Anargyros, *Arch. f. Augenh.* Bd. XLVI. S. 62, 1902.

Of the eight eyes submitted three appeared externally to be normally pigmented, the other five showed more or less of the white condition of the iris known as "wall-eye." The microscopical appearances varied so much that it will be best to describe each separately.

Case I. Two Eyes of a Bull Terrier; the Right normally pigmented, the Left "wall-eyed." The globes are divided sagittally. In the pigmented eye the fundus appears normal; in the albinotic there is a large white patch corresponding to the tapetum.

Microscopical Examination. (*a*) The pigmented eye shows no abnormality. (*b*) The "wall" eye shows complete absence of the stroma pigment while the pigment epithelium and all its derivatives are normally pigmented. In the anterior layers of the iris there is a packing together of the nuclei, suggesting the crowding of the chromatophores in the same layer of the normal eye. It is probable therefore that the chromatophores are present, but devoid of pigment. Traces of Fuchs's, v. Michel's and Grunert's clump cell spurs are found, associated with fibres running from the dilatator to the sphincter.

It is interesting to note that the pigment which is normally found in the sphincter and dilatator is preserved. Confirmation is thus afforded of the view that this pigment is of the same epiblastic origin as that of the retinal epithelium and the clump cells. The observation also lends a certain amount of support to the view that the sphincter and dilatator are themselves derived from the retinal epithelium.

In the ciliary body the stroma pigment is absent, while clump cells are fairly abundant, especially towards its posterior part. In the choroid both stroma pigment and clump cells are completely absent. The chromatophores of the sclera are also absent.

The pigment epithelium is everywhere normal. There is no pigmentation of the conjunctival epithelium or conjunctiva in either eye.

Case II. Two Eyes from a Mongrel Collie. Young male. Curly hair; fawn colour all over; no "blue" in coat. In the right eye the iris is white, in the left brown. The eyes were fixed in Zenker's solution within ten minutes of death by anaesthetic.

The pigmented eye is divided horizontally, the wall-eye sagittally. The fundus of the former appears to be normally pigmented, in the latter the pigmentation posteriorly is mostly normal, but a large triangular unpigmented area is present on one side, with its base at the ora serrata, and its apex behind the equator.

Microscopical Examination. In this case neither the pigmented nor the albinotic eye is a pure example of its class. (*a*) In the pigmented (L.) eye the ciliary body on one side shows exactly the same condition as in the wall-eye of *Case I*,—absence of pigment in the chromatophores, with its preservation in the pigment epithelium and in the clump cells. The chromatophores cease almost abruptly at the root of the iris; at the junction of the ciliary body with the choroid one or two of them trespass for a very short distance anterior to the ora serrata, in the outermost layer of the ciliary body. Possibly the iris on the same side is a little less deeply pigmented than on the opposite; if there is any difference it is very slight. The choroid is normally pigmented, and shows no difference on the two sides. The scleral chromatophores are absent anteriorly on the side of the unpigmented ciliary body, normal elsewhere. The retinal pigment is normal.

Pigment is present in the conjunctiva, the conjunctival epithelium, and the superficial layers of the sclero-corneal junction.

(*b*) In the "wall" eye (R.) the albinism of the stroma is perfect in the iris and almost perfect in the ciliary body, a few chromatophores only being found in its posterior and outer layers. Fuchs's, v. Michel's, and Grunert's spurs are represented, but are poorly developed. The pigment of the retinal epithelium, clump cells, dilatator and sphincter is preserved. Except in the triangular area already mentioned the choroidal stroma is normally pigmented, the chromatophores commencing a little in front of the ora serrata on one side, and a little behind it on the other. The pigmentation is, however, decidedly lighter than in the other eye. In this globe also the pigment of the retinal epithelium is not normal in the posterior part of the globe. Apart from the region of the tapetum, where pigmentation is normally absent, there are areas of unpigmented cells alternating with pigmented. The condition terminates abruptly at the ora serrata, beyond which the pigment epithelium is normal. In the triangular white area the pigment is absent from the stroma; in the epithelium it is present in patches, as over the rest of the choroid.

Scleral pigmentation is present posteriorly, but is also lighter than in the opposite eye. Anteriorly it is absent in the deeper layers, but pigment is present in the conjunctival epithelium and stroma, and in the most superficial layers of the sclera. Inasmuch as chromatophores are absent elsewhere in the anterior part of the eye, it is probable that these cells in the conjunctiva and sclera are derivatives of the pigmented surface epithelium. The simultaneous persistence of the epiblastic pigment outside and inside the globe is of interest.

Case III. Both Eyes of a Bitch, aged 10 *Months. Mongrel of a white Bull Terrier and Irish Terrier.* Left eyelid sandy; sandy patch on left ear; greater part of back and distal half of tail sandy. Otherwise coat white. No black skin anywhere. Nose pink. Mouth not examined. The dog hears well. There is a red glare from the eyes in light. Both irides are white, but in the left there are two brown patches, one below, one upwards and inwards. The globes are divided sagittally. The fundi appear to be normally pigmented.

Microscopical Examination. (*a*) In this case no part of the uveal tract is entirely free from stroma pigment. In the right eye, which seemed externally to be purely albinotic, there is a small patch of pigmentation in the stroma of the iris root on one side. On this same side the ciliary body and choroid are pigmented, and pigment is present in the deep layers of the sclero-corneal margin; in the ciliary body and in the anterior part of the choroid the pigmentation is lighter than usual; posteriorly it is of average density; the sclera is normally pigmented behind. On the opposite side the stroma pigment is totally absent from the iris, ciliary body and sclera; from the choroid it is also absent, except that a few chromatophores are found close to the nerve entrance; the pigment of the retinal epithelium, of the clump cells, and of the sphincter and dilatator is undisturbed. The spurs of Fuchs and v. Michel are well marked.

(*b*) The left eye shows exactly the same arrangement, except that corresponding to the spots visible during life, pigment occurs further out on the iris. The pigmentation in these spots is considerably less dense than in the normal dog's eye.

The conjunctiva and superficial layers of the sclera are not pigmented in either eye[1].

Case IV. Both Eyes of a wall-eyed Dog (received in formaline December 19, 1907). Iris white in one eye, brown in the other. No other particulars.

The globes are divided sagittally. In the pigmented eye the fundus appears to be normal. In the unpigmented there is a very large area in which the fundus is white with a few gray spots. It is chiefly in the ? lower half (orientation is not quite certain), but in the periphery encroaches very largely on the upper. On the other hand the pigmented area encroaches a little on the lower half of the globe at the papilla. From the ora serrata forwards the uvea is lined by normally dense pigment.

Microscopical Examination. (*a*) The pigmented eye shows no abnormality of the stroma pigment. The retinal pigment is normal in the iris and ciliary body; in the lower part of the choroid it seems to be less dense than normal, especially in certain patches.

(*b*) In the other eye the arrangement of the stroma pigment is practically the same as in *Case III.* The iris is almost free from pigment; only one or two chromatophores occur, quite at its root. On the same side, however, the ciliary body and choroid are pigmented. On the opposite side the iris and ciliary body are unpigmented, while the choroid is pigmented only close to the disc. The pigment epithelium is abnormal. On the side on which the choroid is pigmented there is no pigment in the epithelium, except in the extreme periphery. This probably corresponds with the tapetum. On the opposite side pigment is present in the epithelium, but is very scanty, individual cells being found which are quite unpigmented. This condition extends to the ora serrata, and represents a higher degree of the same abnormality in the other eye. It is noticeable that on the same side clump cells are very scanty in the ciliary body. In the situation where they are usually found groups of unpigmented cells occur, which differ from the ordinary muscular or connective tissue cells of the part. They probably represent clump cells devoid of pigment.

The spurs are poorly developed. The conjunctiva and superficial layers of the sclera are not pigmented in either eye.

Remarks. The condition known as "wall-eye" is, therefore, one of partial albinism, due to lack of mesoblastic, or stroma, pigment, while the retinal pigment and its derivatives are present, but, especially over the choroidal area, there may be less pigment than in normal eyes. The distribution of the abnormality is frequently irregular. As regards the stroma pigment examples have been given of the following variations. (1) Its total absence in the whole uvea (*Case I* (*b*)). (2) Absence of pigment in one lateral half of the uvea, and irregularity of distribution (small amount in the iris) in the other half (*Cases III, IV* (*b*)). (3) Absence of pigment in the anterior half of the uvea (iris and ciliary body), with almost normal density of pigmentation, except for a triangular unpigmented area, in the choroid (*Case II* (*b*)). (4) Absence of pigment in the ciliary body of one side, with normal pigmentation everywhere else (*Case II* (*a*)). The pigmentation of the sclera usually follows the pigmentation of the choroid. Where the pigmentation of the choroid was unilateral it was always in the same half of the eye as the pigmentation of the iris. The series throws no light on the question whether the choroid may be unpigmented while the iris is pigmented; to settle this would demand the examination of a number of externally normal eyes.

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[1] The microscopic appearance of the iris and choroid of this dog is reproduced in Plate ϵ, Figs. 1—5: see Description of Plates at the end of this Chapter.

Case IV (*a*) is an example of deficiency in the epiblastic system of pigmentation alone. *Cases II* (*b*), and *IV* (*b*), are instances of simultaneous deficiency in both systems, and are therefore transitional towards the condition of complete albinism. The naked eye appearances of such eyes are as follows. If pigment be present in the stroma but absent in the retinal epithelium the fundus appears normally pigmented. If it be absent in the stroma but with its normal distribution in the retinal epithelium there will be a white patch corresponding to the tapetum (where the epithelium is normally unpigmented), while the rest of the fundus is pigmented but not so darkly as normally. When pigment is absent from both systems the fundus, naturally, is white.

Except that it is an abnormality, the wall-eye of the dog corresponds to the light blue human eye. The dog's iris is white because its stroma is much thicker and coarser. It is composed of intertwining bundles of fibrous tissue, much like fibrous tissue from any other part of the body, and quite unlike the delicate branching cells of the human iris. Hence light is reflected, not partially transmitted, and the retinal pigment does not show through. Over the sphincter the fibrous layer is thinner, probably because of the necessity for freer movement in this situation. Elastic fibres are present in the dog's, but not in the human iris, except in association with the largest vessels.

B. *Albinotic Eyes.*

Case I. The eyes in this case were those of the albinotic Pekinese spaniel Tong I. Her ancestry will be more fully discussed in the chapter on albino animals, but reference has already been made to her in the chapter on the Albinotic Hair. She was suffering in January, 1911, so severely from fibroid growth of the uterus, that she had to be killed. She was a fairly old dog. The organs were sent for examination to Dr Lowe of Aberdeen by Dr W. Bulloch of the Department of Pathology, at the London Hospital, who had most kindly undertaken a *post-mortem* examination. The eyes were sent to Mr Coats, whom we have to thank for the report below.

Clinically the dog might pass for a complete albino, she exhibited bluish irides and red reflex from the pupils. Macroscopically the hair exhibited, chiefly on the head, at times the palest yellow colour. She had the dark brown "spectacle marks" (see p. 343) of the class. Microscopically the hairs even from the spectacle marks showed no pigment granules. The colouring was, as in most albinos, solely diffused pigment. Thus she may be classed as a complete albino as far as the hair is concerned. The following account shows that the eye is only partially albinotic.

Report on the eyes of the albinotic Pekinese Bitch Tong I. The following remarks are founded on the eyes submitted to me by K. Pearson. The albinism of the eyes is only partial, the distribution of pigment, which is identical in both eyes, being as follows:—

(1) In the iris the pigment epithelium is quite deeply pigmented. A moderate number of isolated pigmented cells are scattered throughout the stroma. Some of these are no doubt clump cells, but others have neither the characteristic appearance nor distribution, and are probably true chromatophores. At least one pigmented cell is found in the ligamentum pectinatum, where, it is believed, clump cells do not occur. A few pigment granules are present in the sphincter and dilatator.

(2) In the ciliary body the distribution of pigment is similar, except that pigmented cells are more scanty in the stroma, and more of them are of the clump cell type. The outer layer of the epithelium is well pigmented.

(3) In the choroid the stroma pigment seems to be absent. The epithelium is remarkable for the extreme paleness of its pigment. Anteriorly some granules of approximately normal tint occur; posteriorly granules are present in the cells, but are either devoid of pigment or have only the faintest brown tinge.

(4) The scleral chromatophores are apparently absent.

Case II. Report on the eyes of an eleven weeks old albino Pekinese Puppy. By C. H. Usher. Male pup of *Jan Van* × *Mairi Bhan*, born 12 Dec. 1909, died 27 Feb. 1910. It was chloroformed, for it was thin and miserable, losing in weight, and had an inguinal hernia. Eyes had red pupil and grey iris. Right eye placed in 7 per cent. formalin, left eye in Zenker's fluid.

Microscopical Examination. The epiblastic layers of iris and ciliary body are pigmented; the ciliary body layer is darker than the two iris layers; pigment is light brown; no pigment present in any other part of the eye; in retinal pigment layer, choroid, and in stroma of iris and ciliary body there is not a trace of pigment.

Other Cases. By C. H. Usher. The five pups of *Spook* × *Idiot*, born 20 Dec. 1910. Three males and two females. (1) (male) and (2) (female), died day of birth, 20 Dec. 1910.

Cases III—V. Eyes of one day old Pekinese Pups. The description of eyes and skin applies equally to each. Coat white all over; no spectacle mark; tail, and indeed most parts, are covered with straight hair; body well formed; snout blunt like other Pekinese dogs; mucous membranes, roof of mouth, and nose are pink, and have no pigment; limbs well developed; toes normal, nails present. Eyes: firmly closed lids separated with scissors; eyeballs translucent; iris colourless; ciliary processes clearly seen through iris; they are dark and probably pigmented. In opened eye fundus looks nearly white; ciliary body nearly dark brown; faint brown tinge on posterior aspect of iris.

Microscopical Examination. No pigment at limbus; iris and ciliary body epiblastic layers pigmented; in the iris these layers are not deeply pigmented, the stained nuclei of the cells are visible; the more posterior of the iris layers is unpigmented for a considerable distance at ciliary end of iris; pigment in epiblastic layer of ciliary body comes to an abrupt end at ora serrata; no pigment in stroma of iris and ciliary body or in choroid and retinal pigment layer.

Cases VI—VIII. Eyes of Pekinese albino Puppies two to four weeks old.

(3) Female pup, died about 5 Jan. 1911.

(4) Male pup, died 12 Jan. 1911.

(5) Male pup, died 23 Jan. 1911. The last two were killed by the mother. The coat colour of the five pups is the same. The macroscopic external and internal appearance of the eyes of each pup is the same. On microscopical examination the depth of pigmentation and distribution of pigment are seen to correspond very closely in the eye of each pup. In all, the only parts of the eye containing pigment are the epiblastic layers of iris and ciliary body; the pigment is light brown; the pigment ends abruptly at ora serrata and there is no pigment in the part of the more posterior iris pigment layer next ciliary body. The retinal hexagonal cells are completely pigmentless.

SECTION III. *Partial Albinism in the Eyes of Mouse, Rabbit and Horse.*

A. *Mouse.*

By G. COATS, M.D.

Case I. Common House Mouse. (From E. Nettleship.) Eyes black. Normal pigmentation is shown. The stroma and retinal pigment are both very dense, so that details are obscured. It is impossible to distinguish chromatophores from clump cells. The sphincter iridis is free from chromatophores, but shows a sprinkling of pigment granules; the dilatator is invisible. In the ciliary body the stroma pigment is mostly accumulated in the inner layers. In the choroid pigmentation is very dense, but the chorio-capillaris and membrane of Bruch are free. Remains of the hyaloid artery project permanently into the vitreous in the mouse; they are clothed on their outer surface by a layer of pigment; the sections do not show with certainty whether this is stroma or retinal pigment. Pigment is present in the sclera at the site of the perforating vessels[1].

Case II. Fancy Mouse. (From E. Nettleship.) Coat piebald; white and dark slate colour. Eyes black; no red reflex through iris either in daylight or on ophthalmoscopic examination in the dark room (pupils not dilated by atropine). The eyelids are pigmented.

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[1] The microscopic appearance of the iris as shown in the normally pigmented mouse is reproduced in our Figs. 10 and 11, Plate ε: see description of Plates in Section X of this chapter.

In this case the retinal pigment is normal and the stroma pigment is practically absent; the condition corresponds to *Case I* (*b*) of the canine series. A few clump cells are present in the iris, and there are scattered pigment granules in the sphincter. The choroidal stroma is entirely free from pigment. One small patch of pigment, presumably mesoblastic, is found outside the sclera close to the nerve; it is only present in a single section. Otherwise scleral pigmentation is absent. The pigment round the hyaloid artery is absent; since it is the mesoblastic pigment which is deficient in this eye it is probable that the normal pigment round the hyaloid artery is mesoblastic in origin.

Case III. Fancy Mice. (From E. Nettleship.) Two mice; coat piebald—"chocolate" and white. In daylight the eyes (iris and pupil together) have a very dark ruby or garnet colour. The *stroma pigment* seems to be normal in the iris. It is present but only slightly in the ciliary body. In the anterior part of the choroid it is almost absent, but a few small tracks of it are found. Posteriorly the pigmentation again becomes a little more abundant, and a fairly dense group of chromatophores is found by the side of the nerve entrance. Scleral pigmentation is absent except near the optic nerve. The hyaloid artery is not pigmented. *Retinal pigment.* The two layers of epithelium on the back of the iris show a considerable difference in density of pigmentation. The posterior layer has approximately the normal tint, while the anterior is much lighter. The greater paleness of the anterior layer is due partly to less crowding of the cells with granules, partly to a lighter colour of the granules themselves. Over the ciliary body and the choroid the pigment epithelium shows the same paleness as the anterior layer of the iris; the acicular pigment granules in the epithelium posteriorly are much finer and lighter in colour than in the normal eye.

The hairs are more lightly pigmented in this case than in the last two.

Case IV. Mouse with a light red sandy Coat. Eyes are moderately deep red in daylight; irides translucent on ophthalmoscopic examination in the dark room. *Stroma pigment* is present throughout the uveal tract, but is small in amount. It is of a very pale yellowish brown colour, and tends to leave a little clear space round the nuclei in the iris. It is more abundant in the iris than in the choroid and is very sparse in the ciliary body. Scleral pigmentation is absent. *Retinal pigment*; in the iris and ciliary body the retinal pigment is totally absent and the sphincter, dilatator and ciliary muscle are also unpigmented. On the choroid the epithelium is mostly unpigmented, but in places, chiefly at and beyond the equator, a few light-coloured, coarse granules are present towards the inner part of the cells. The hyaloid remains are unpigmented[1].

Case V. Japanese Waltzing Mouse. Coat white with some light sandy patches. Eyes bright pink, and irides translucent in dark room. *Stroma pigment* is totally absent in the iris and choroid. A few granules occur in the ciliary body. There is no scleral pigmentation. *Retinal pigment* is absent in the iris. In the ciliary body the outer layer of the epithelium is lightly pigmented. At the fundus the epithelium is almost unpigmented; only anteriorly a few cells show scanty granules towards their inner surface. The hyaloid artery is unpigmented[1].

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[1] The microscopic appearances of the iris and choroid of this mouse are reproduced in Plate ϵ, Figs. 14 and 15: see description of Plates, Section X of this chapter.

Case VI. White Mouse. In a mouse with pure white coat no pigment was present anywhere in the eye[2].

B. *Rabbit.*

By G. Coats, M.D.

Case I. Fancy Rabbit. Coat white, with slaty patches on the back posteriorly, on the ears and around the eyes. Both the hairs and the skin of the eyelids are pigmented. Some of the pigmented hairs are black, others brown. Irides light blue; not translucent. Fundus apparently normal. The condition is similar to that found in *Cases I* (*b*) of the canine and *II* of the mouse series. The *stroma pigment* is totally absent from the iris, ciliary body and choroid, while the *retinal* is normal. In the iris the pigment epithelium shows a number of small plications, not due to folding of the iris generally; from these pigment tends to radiate for a short distance into the stroma. The various "spurs" are not well represented, though v. Michel's and Grunert's seem to be indicated. Typical clump cells are not abundant, but both the sphincter and dilatator are pigmented.

Case II. White Rabbits. In two rabbits with wholly white coats no trace of pigment was found in the eye.

By C. H. Usher.

Case III. Rabbit (*Partial Albino*) *with red Pupils.* It is a wild rabbit and there are said to be no tame ones in the district. A dark mouse-coloured rabbit was obtained from same place in 1910.

Coat (seen) presents a curious appearance. On anterior part of back the colour is light yellowish red-brown; posterior part is same colour as normal wild rabbit; middle part of back has much white hair mixed with normal wild rabbit hairs. Hind legs have normal colour. Right foreleg of same colour as anterior part of back; left foreleg normal colour. Face is white down to mucous membrane of nose; rest of face including part surrounding the eyes is of normal colour. Neck is white in front, except lower part, which has the peculiar light brown colour which is continuous with that on anterior part of back; right ear normal; left ear light brown like that on back.

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[1] The microscopic determination of pigment granules in the eye of this Japanese waltzing mouse is of primary importance. No "clinical" examination would suffice to discover them, nor to differentiate the eye of the waltzing mouse from that of the albinotic white mouse. It is important that the eyes of many more Japanese mice should be examined and also those of "extracted recessives," *i.e.* the albinotic offspring of hybrids between the Japanese and white mice. K. P.

[2] The microscopic appearances of iris and choroid of the completely albinotic mouse are reproduced in Figs. 12 and 13 of our Plate ϵ: see Section X of this chapter.

Eyes[1] (preserved in 10 per cent. formalin) have a nearly complete circle of dark pigment at limbus; fundus uniformly pale chocolate brown; iris grey blue (almost wall-eye) with narrow dark band at pupil margin. Opaque nerve fibres present as usual in fundus.

Microscopical Examination. Pigment is found only in epiblastic structures. Posterior layers of iris, retinal pigment layer and epiblastic pigment layer of ciliary body are very dark; choroid is pigmentless; no pigment in stroma of iris and ciliary body; epithelium at limbus is darkly pigmented.

Case IV. White Russian Rabbit. Received March, 1903. The iris in each eye was brown except for a white patch extending from pupil to root of iris occupying about one-fourth of the iris in one eye and one-third in the other and having well-defined margins. The lens opaque in one eye; the fundus in the other showed, during life, a white patch. On opening the eyes the anterior part seemed to be dark, but the posterior and larger portion decidedly pale having a faint brown tinge, the boundary between light and dark forming an irregular line. Microscopically pigmentation apparently normal except at the white patch on the iris and pale portion of the fundus. The white part of iris showed no pigment at all in the stroma; posterior epithelium very dark, not lighter at the white patch than elsewhere. Pigmentation of ciliary body both stroma and epithelium as dark where it joins the white patch of iris as elsewhere. Choroid at the posterior parts of fundus entirely devoid of pigment. Retinal epithelium equally pigmented over all parts of the fundus except at one part of the light portion of fundus where a few of the cells contained only a few pigmented granules.

C. *Horse.*

By G. Coats, M.D.

Case I. Two eyes from the same horse; received from C. H. Usher of Aberdeen. They were sent to C. H. Usher dry, in cotton wool, and have suffered from lack of early fixation. The irides are white, with a sprinkling of pigment.

One eye is divided sagittally, one horizontally. Macroscopically the retinal epithelium is normal as far back as the ora serrata, but the fundus is very pale. The condition is essentially similar in both eyes; the fundus is rather more deeply pigmented in one than the other.

Microscopically the *stroma pigment* seems to be absent from the iris; there are no branched chromatophores, but only rounded cells like clump cells, and diffusely scattered pigment granules, probably derived by *post-mortem* disintegration from the pigment epithelium. There is a quantity of pigment on the anterior surface of the iris, among the spaces of Fontana and in the anterior half of the ciliary body, but here also proper branched chromatophores are not found, and it is probable that most, if not all of the pigment, has been washed from the disintegrating pigment epithelium. The ciliary body shows slight pigmentation in the form of clump cells. The choroidal stroma is unpigmented. The *retinal pigment* seems to be normal throughout. The cells are breaking down on the back of the iris, and are stripping freely from the choroid. The "grape-cluster" at the edge of the iris is normally pigmented. Although masked by *post-mortem* change it is probable that this case belongs to the same class as *Cases I* (*b*) of the canine, *II* of the mouse and *I* of the rabbit series and *XI*; the stroma pigment being totally absent and the retinal preserved.

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[1] From Messrs Macleay and Son, Inverness.

Remarks. The results correspond on the whole with those obtained in the case of the dog. Some additional points are also illustrated. *Case III* of the mouse series furnishes an example of full pigmentation of the iris stroma with deficient pigmentation of the uvea posteriorly; this is the converse of *Case II* (*b*) in the canine group. The mouse series illustrates much better than the canine the fact that variation occurs not only in the distribution and amount of pigment, but also in the depth of its colour. This is true both for the stroma pigment (*Cases IV* and *V*), and for the retinal pigment (*Cases III, IV, V*).

The difference in depth of pigmentation between the two layers of epithelium on the back of the iris in the same eye (*Case III*) is of interest.

The mouse series also furnishes more typical examples of abnormalities of the retinal epithelium, forming transitional stages towards complete albinism; in *Case V* pigment was only present in the ciliary body and anterior part of the choroid, and in *Case IV* only in the anterior part of the choroid. *It required microscopical examination to distinguish the eyes of Tong I and of Case V from a purely albinotic eye.*

The conclusion arrived at from a study of all the above cases is that practically any conceivable variation in the distribution, quantity and depth of colour of the pigment may be found, and any combination of such variations of the meso- and epiblastic pigmented structures respectively. In the present series partial albinism of the eye was always associated with partial albinism of the coat[1] and complete albinism of the eye with complete albinism of the coat.

SECTION IV. *Partial Albinism of the Eye of the Horse* (*Wall-Eye*).

By C. H. USHER.

Two wall-eyes from different horses were examined, both of them kindly sent by Sir John MacFadyean, also three normal eyes from two other horses. None of the eyes were examined during life.

Case I. The normal Horse Eye. The normal eyes were removed several hours—twelve hours in one case—after death and placed in 5 per cent. formalin. Two of the eyes were from a dark brown horse, the third one from a grey horse. After freezing, one eye from the brown horse was opened equatorially, the other two sagittally. Microscopical sections were made from these last two eyes.

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[1] That is to say there was some colour in the hairs of the coat. The problem as to whether that colour was due to *granular* pigmentation is another matter: see our chapter on the Albinotic Hair.

Macroscopically the following appearances were seen in the three eyes. At the limbus of the conjunctiva a continuous dark brown band surrounding the cornea. A large darkly pigmented area on the part of the conjunctiva which adjoins the narrower posterior (or temporal) end of the cornea. The iris has two distinct zones: (1) the more peripheral ciliary zone, (2) the pupillary zone. The ciliary portion forms by far the larger part of the iris. It has a dark brown colour, and presents on its anterior surface fine concentric folds, also much larger radial folds. The pupillary portion forms a zone round the horizontally oval pupil. This zone is broadest above and below the centre of the pupil, where it forms about one-third the width of iris. It is of a much darker brown colour than the ciliary zone. The pupillary margin of this pupillary zone forms a narrow very dark line except at the upper part where the conspicuous, irregular, black protuberance—the corpus nigrum—projects from the pupillary edge into the anterior chamber and encroaches upon the pupillary space. When the iris is viewed in section it is obvious that the ciliary zone is much thicker than the pupillary zone. The ciliary body is exceedingly dark, in marked contrast to the lighter anterior portion of the fundus.

Fundus oculi.—After removal of the opaque retina the inferior portion of the fundus presents a nearly uniform exceedingly deep brown colour which, however, is distinctly lighter anteriorly, *i.e.* immediately behind the ciliary body. The upper limit of this dark lower part of the fundus is sharply defined by the lower edge of the tapetum. In the lower part of the fundus close to the tapetum is the optic disc which is circular, cupped, and of a yellow colour. The tapetum has a brilliant blue colour, especially at its lower portion, where it is in marked contrast to the deep brown of the lower portion of the fundus. Towards the upper part of the fundus the blue colour lessens and gradually shades off into the brown colour at the upper part of the fundus. The brown colour of the upper part of the fundus is not so dark as that of the lower part[1].

Microscopical Examination. The pigment at the limbus conjunctivae is confined to the anterior epithelium where it is most abundant in the deepest layers. Pigment is not found in cornea and only in small quantity in sclerotic. The posterior (epiblastic) layer of the iris, consisting of the usual two strata, is deeply pigmented; at the pupil it is continued for a short distance on to the front of the iris; at the thick ciliary zone of iris it has a uniformly even anterior surface, but at the pupillary zone it becomes thicker and less regular, and sends off small spurs into the iris stroma. The endothelium on the anterior surface of iris is pigmented. The stroma of the iris in its pupillary and ciliary parts is pigmented, most markedly in the latter situation. The stroma pigment is dark brown and appears as a network and as dark, circular, brown discs (clump cells); there are many large pigmented branched cells. Fundus.—The hexagonal cells of the retinal pigment layer are deeply pigmented in the lower part of the fundus, but at the tapetum they loose their pigment, although some of them even upon the tapetum are slightly pigmented; all retain the hexagonal form. The choroidal tissue is darkly pigmented between the large blood-vessels;

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[1] The macroscopic appearances of the choroid and iris of the normal horse are reproduced from drawings by the author on Plate ζ, Figs. 1 and 2.

much of its pigment is in the form of elongated thick bands. The choroidal pigment is as abundant and dark at the region of the tapetum as it is in the fundus below the tapetum. Lamina cribrosa unpigmented[1].

Case II. Wall-eye of Horse. A right eye received in 10 per cent. formalin. *Macroscopical Examination.* At the limbus conjunctivae is a ring of dark brown pigment completely surrounding the cornea. The eye was frozen and opened sagittally. The ciliary portion of the iris is greyish white and presents radial folds and finer concentric folds on its anterior surface, and is much thicker than the pupillary portion. Pupillary zone of iris has a dark slate blue colour; on its anterior surface is a grey layer, except at the margin of pupil which is black or very dark brown; corpus nigrum quite dark. Viewed in section no pigment is seen anywhere on the iris except in its posterior epithelial layer, and this viewed from behind gives the iris a deep chocolate brown colour. The ciliary body at its peripheral (sclerotic) part is seen on section to be yellowish white; this appearance is continuous with the colourless stroma of iris. The pigment in the inner surface of the ciliary body is remarkably dark. Fundus.—The choroid has a pale brown colour[2], the part below the tapetum (lower part of fundus) being darker than the rest. The tapetum has a well-defined lower margin. One portion of it, far forwards adjoining its lower margin, has an iridescent green colour. In the upper part of fundus are large areas with but little pigment, and nearly white in colour.

Microscopical Examination. The posterior (epiblastic) layer of the iris is darkly pigmented, and is thicker at pupillary zone; its anterior surface seen in section forms an even line at the ciliary portion of iris, which is much thicker than pupillary portion, but becomes uneven at the pupillary part of the iris owing to small spurs that project from it into the stroma. Corpus nigrum is deeply pigmented. The endothelium on anterior surface of iris is not pigmented. The stroma of iris generally contains no pigment, except the spurs from the epithelial layer above mentioned; but in some sections a small amount of what appears to be true stroma pigment (mesoblastic) does occur. Ciliary body has a deeply pigmented retinal layer; stroma without pigment, some pigment spots seen in a few sections may have been carried in *post-mortem.* Fundus.—The cells of the retinal pigment layer are deeply pigmented in the lower part of the fundus, on the tapetum some are pigmentless, and at other parts of the tapetum they are very slightly pigmented; the cells are all hexagonal. The choroid is unpigmented, and its blood-vessels much distended[3].

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[1] The microscopic appearances of iris and choroid of this horse are reproduced on Plate ε, Figs. 6 and 10: see description of Plates at the end of this chapter.

[2] The macroscopic appearances of choroid and iris of this wall-eyed horse are reproduced from drawings by the author of this section on our Plate ζ, Figs. 3, 4 and 5: see description of Plates at the end of this chapter.

[3] The condition of the arteries and veins of the choroid as seen in microscopical sections varies extremely in different eyes of the same species according as they were distended or empty when the eyeball was hardened. When distended, as in the specimen here described, they have the effect of making the choroid as a whole more than twice as thick as in other specimens where they were empty. The microscopic appearances are reproduced in Figs. 8 and 9 of our Plate ε: see description of Plates at the end of this chapter.

Case III. Wall-eye of Horse. A left eye received in wool moistened with formalin was then placed in a solution of 7 per cent. formalin. *Macroscopical Examination.* When the eye was placed with the cornea towards the window the pupil had a distinctly red colour. This was even more marked when the eye was held up to the light with the cornea away from the window. At the limbus conjunctivae is a ring of dark brown conjunctival pigment. The eyeball was frozen and opened sagittally. The ciliary region of the iris is quite white with the exception of three small brown spots, two below and one above, and a large brown patch above the nasal end of pupil from which a pigmented band extends for a considerable distance along the periphery of upper part of iris. The pupillary portion of iris has a slate grey appearance. As in the previous case there are concentric folds on the iris and broader radial folds. The margin of the pupil consists of a narrow deeply pigmented band, much darker than the slate grey colour of the rest of the pupillary part of iris, and the corpus nigrum is very dark brown or black. On the nasal part of the pupillary zone of iris is a small brown patch. Looked at in section the white colour of the iris and ciliary body contrasts strongly with the dark (epiblastic) layer lining its posterior surface; the ciliary zone is considerably thicker than the pupillary portion. The pigment epithelium of the ciliary body is very dark and ends posteriorly at a well-defined line at the light-coloured choroid. The whole of the choroid is exceedingly pale, much paler than in the last eye (Case II); the lower part has a nearly uniform light brown colour, but above the optic disc, the part corresponding with the tapetum is almost white, passing into a very pale shade of brown at the upper part. In the anterior part, however, of this upper region there is a large, well-defined, roughly circular area which has a darker brown colour even than that of the lower part of the fundus. In no part of the fundus is there any greenish or bluish iridescence. The optic disc, as in the previous case, has the same characters as in the normal horse's eye.

Microscopical Examination. The epithelial cells at the limbus conjunctivae are deeply pigmented. There is no pigment in the loose tissue beneath the conjunctival epithelium. Cornea and sclerotic are not pigmented. The retinal layer of the iris uniformly deeply pigmented from pupil to ciliary body; the stroma in the ciliary portion of the iris is unpigmented in the part below the pupil; in the part of the iris above the pupil, in sections taken from the nasal half of eye, there is a considerable amount of dark brown pigment arranged in a similar manner to that in the normal iris; this pigment diminishes and becomes limited to the periphery as the sections approach the temporal half of iris.

This pigment in the stroma corresponds to the large brown patch which had been seen with the naked eye. In the pupillary portion of the iris the stroma contains no branched pigment cells, but there are long darkly pigmented narrow bands, most of which appear to be connected with the posterior pigment epithelium and are probably of epiblastic origin. Ligamentum pectinatum pigmented in the upper part of the sections and in a much less degree in the lower part. Choroid: no pigment found in any part of it, except at the large dark area in the upper portion of the nasal half of the fundus; in this area the choroid contains a large quantity of dark pigment. The *retinal layer* of hexagonal cells is pigmented in the lower part of the fundus. In the region of the tapetum the cells lose their pigment, but not their hexagonal shape. They contain much pigment at the dark area at the upper nasal part of the fundus, while above this area they have only a small quantity of pigment. Seen on the flat, most of the hexagonal cells which were examined from the tapetum contained some pigment, some containing more pigment than others, and none having much.

The colour of the coats of these two wall-eyed horses could not be ascertained. In a few living wall-eyed horses the colour of the coat and the appearance of the eyes were as follows:

A. A twelve year old bay Clydesdale horse, seventeen hands high, with white on centre of face not extending to eyelids; feet white except right forefoot. Eyes.—Right is a partial wall-eye, left is a complete wall-eye. Right iris generally brown; on its white ciliary zone a narrow, crescentic patch embracing nasal end of pupillary zone; on the brown pupillary zone are three grey areas, one above and one below pupil, the third adjoins the white crescentic patch on ciliary zone. Pupil, corpus nigrum and pupillary margin as in an ordinary horse. Left iris white all over ciliary zone; pupillary zone is light grey with usual dark margin at pupil. On ophthalmoscopic examination the red part of the right fundus was darker than that of the left eye, and no choroidal vessels could be seen; in left eye choroidal vessels clearly seen; no red reflex through iris in either eye.

B. Bay horse with white hind feet and one white forefoot, only other white part is face and lips; eyelashes white; in both eyes iris is white in its outer two-thirds and bluish grey at pupillary zone; on ophthalmoscopic examination tapetum bluish white, choroidal vessels visible at red parts of fundus.

C. Dark bay highland pony mare, age seven, called Silver eyes; a few white hairs on centre of forehead and over left nostril, none elsewhere; eyelashes dark; feet black. Eyes.—Right complete and left almost complete wall-eye; outer two-thirds of iris is white with the exception of a darkly pigmented patch at temporal part in left eye, the white appearance is like that of the human sclerotic; pupillary zone of iris, narrow as usual at anterior (nasal) and posterior (temporal) parts, is bluish and has a fine grey tissue on it which gives a veiled appearance; corpus nigrum and uveal ring round pupil quite dark; on ophthalmoscopic examination in daylight tapetum is yellow-green; fundus red below tapetum.

D. Bay mare with white hind feet, white strip on right forefoot and white at centre of forehead; no white near eyes; lashes dark. Eyes.—Both complete wall-eyes, larger peripheral part of iris is white, pupillary part is bluish grey; conjunctivae at limbus deeply pigmented; on ophthalmoscopic examination tapetum is white, rest of fundus is pink.

Conclusions. The *most marked microscopical difference* between these normal eyes and wall-eyes of the horse is in the pigmentation of the mesoblastic tissue of the uveal tract. In the wall-eyed horse the pigment in this tissue is either altogether absent or it only appears in patches. The pigmented limbus conjunctivae is no darker in the normal eye than in the wall-eye; this pigment is in the anterior epithelium (epiblastic). The conspicuous white appearance of the iris in the wall-eye is caused by the absence of pigment from the stroma and anterior endothelium. The pigmentless stroma at the ciliary zone of the iris is sufficiently thick to prevent the pigmented posterior layers of the iris from being seen; the pupillary zone of the iris is not quite white like the ciliary zone, for the stroma is less in quantity at this much thinner portion of iris, and so allows the dark uvea to be seen through it and in consequence a slate blue colour is produced. The epithelial pigment layer at the posterior surface of the iris and the outgrowths from it—corpus nigrum and the processes in pupillary zone—are just as dark in the wall-eye as in the normal eye, so is the pigmented retinal layer of the ciliary body, but there is no pigment or only patches of it in the stroma of iris and ciliary body of the wall-eye.

The fundus of the wall-eye is a much lighter brown than that of the normal eye which is very dark, also amongst the wall-eyes there may be considerable differences in the appearance of the fundus. In horse (Case III) the fundus was much lighter than in horse (Case II). The tapetum has less blue-green iridescence than in the normal eye, and this may be altogether wanting (horse, Case III). Darker patches may occur in the wall-eye fundus. Microscopically the pale brown fundus is distinguished from the dark brown—normal—principally by absence of pigment from the choroid. In both, the hexagonal cells of the retina are pigmented. At the dark patches in the light fundi pigment is present in both retina and choroid. The hexagonal cells from the lower part of the fundus are more deeply pigmented in the normal eye than in the wall-eye; this conclusion was arrived at by examining the cells on the flat after they had been separated from the choroid. There was no marked difference between those of wall-eye (Case II) and those of the normal eye, but there was a marked difference between the lightly pigmented cells of wall-eye (Case III) and the darker cells of wall-eye (Case II) and of the normal eye (Case I).

SECTION V. *Notes on almost completely Albinotic Horses.*

By E. NETTLESHIP.

Case I. Albinotic Horse. In 1907 I had the opportunity of examining a very light cream-coloured mare pony at Whitehill in Hampshire. She stood about 13½ to 14 hands high and was quite 10 years old; coat a pure light cream colour all over, hoofs quite white, skin everywhere pink, including external genitals, mammae and mucous membrane of inside of mouth, not a trace of black or other pigment visible anywhere. Irides white with a slight tinge of blue as to the peripheral two-thirds of their width, the pupillary zone, equalling about one-third, quite brown with a suggestion of reddish tint; the brown was of course due to the colour of the posterior epithelium showing through this, the thinnest, part of the iris; the slight reddish tinge was probably due to the combined effect of the blood in the vessels and the colour of the sphincter muscular tissue; corpora nigra quite black as in a normal horse, and lower edge of pupil bordered by a narrow line of similarly black colour due to the pigment epithelium curving round from the hinder surface. Pupils of the normal oval; they shone of a dullish, but quite distinct, red colour in the daylight (the sky was overcast and the light therefore dull), but were said to be bright red in sunlight. Ophthalmoscopic examination showed (1) the ordinary "metallic"—*i.e.* in the horse green or bluish green—reflex from the tapetum, (2) bright red from the rest of the fundus, and (3) on these red parts of the fundus the choroidal vessels were seen by direct examination with great distinctness. No appearance of choroidal pigmentation could be made out in any parts of the fundus that came into view, and I made as wide a survey as possible. The optic discs did not happen to come into view and I made no special search for them. The animal was said to see quite well; she was not intolerant of light and the eyes were perfectly steady.

This albino's mother was described as a "spotted grey," which I understood to mean grey with dappled marks, but light grey with discrete dark spots may have been intended. The albino's father is a "Norwegian" pony, still living at the time of my visit and aged about 20, and I went to see him. His colour was called "dun," and I found his summer coat (I saw him at the end of June) a light yellow bay, much the same colour as the yellower parts of the coat of an Alderney cow; the winter coat was said to be a sort of slaty grey, so different from the summer colour that some people seeing him in winter had mistaken him for a different animal. He was a sure sire and had begat many other foals, but no other cream coloured one except the subject of this note. His father (paternal grandfather of my albino) was of about the same colour and was brought from Norway; he had a sister (paternal aunt of my albino) who was cream coloured all over like her. She, like her brother, came from Norway. The owner of the "dun" father said he believed that dun and also cream ponies are common in Norway. Nothing could be learnt about the ancestry of the albino's mother.

Cases II and III. Albino Horses. Plate LL (121).

The figure to the left shows the mother of the other two belonging to Mr Frederick Armstrong, Veterinary Surgeon of Penrith, Cumberland. In November 1908 he wrote to me that he originally bought her at a London auction out of one of the coaches. Her pedigree is therefore unknown. He describes her coat as roan and white. She had to be destroyed three months afterwards owing to an accident and the eyes were sent to me. Macroscopically, they were normally pigmented in all parts. They were not examined microscopically but were opened and examined carefully with the naked eye. She had four foals while in Mr Armstrong's possession; the first two by a dark brown horse called Diamond City; "They were beautiful dark brown with black points." She was then mated twice to a horse called Active Goldfinder, a dark chestnut with a white spot on forehead, white near fore and near hind leg and spot on the off fore coronet. There is no account in the *Hackney Stud Book* of any offspring by him and he was dead at the date of writing, November 1908[1].

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[1] Active Goldfinder's pedigree was prepared for a number of generations, his ancestors were chiefly dark chestnut and chestnut, with no roans until the sixth generation back.

The right-hand figure is a filly, aged about 18 months at date of writing. The middle figure, aged about six months, is a colt. In both these the coat is absolutely pure white everywhere, the skin light coloured everywhere, mucous membrane of mouth and lips pink and no patches of pigment. Hairs on nostrils and eyelids pure white, hoofs white. Irides slaty grey, not brown. In the colt there are a few white or whity blue streaks in the left iris. A drawing, made by Mr Hobley at my request, of the front of the eye of one of the young animals shows the ordinary condition of wall-eye in the horse, namely, a bluish outer circle and greyish brown inner circle to the eye. The corpora nigra, pigmented; but as Dr F. Haswell who examined them later described them as darker than the rest of the iris it is probable they were not so dark as in ordinary horses. Dr Haswell found the animals too restive for ophthalmoscopical examination but observed that the pupils became red when light was thrown sideways upon the sclerotic although both Mr Armstrong and he state that the pupils in ordinary light were black.

SECTION VI. *Examination of the Eyes of Mice with different degrees of Albinism, and of dark-eyed Mice for Comparison.*

By C. H. USHER.

Nine mice with dark red pupils, a pure albino mouse, and two mice with black pupils were examined. They were all "fancy" mice. All of the mice were sent alive by Dr John G. C. Ledingham of the Lister Institute, with the exception of mouse (Case XI) received in formalin from K. Pearson.

The eyes were examined ophthalmoscopically after dilatation of the pupils with homatropine. The colour of the pupil was noted when the pupil was undilated. In no case was there nystagmus. In all, the eyes were highly hypermetropic, the fundus being clearly seen on direct ophthalmoscopic examination with a plus 10 or even 12 dioptre lens.

The animals were killed with chloroform. The eyes were enucleated immediately after death and hardened in 5 per cent. formalin. Microscopical sections were made after embedding either in celloidin or paraffin. The sections were stained with haematoxylin and eosin. Some specimens were examined without staining.

Microscopic examination of the eyes shows that the mesoblastic tissue of the iris and ciliary body is small in quantity relatively to the epiblastic tissue when compared with the same tissues in the human eye; the posterior (epiblastic) layers form the greater part of the iris. The choroid and sclerotic are also thin, whereas the retina is relatively thick. In the thin layer of iris stroma (mesoblastic), cells with elongated nuclei are conspicuous. The lens is globular and very large in comparison with the small eyeball.

As will be seen from the following descriptions the distribution of the ocular pigment is usually the same in all the mouse eyes with dark red pupils.

Case I. Coat—white[1]. Pupils—the dark red reflex was easily made out in the left pupil, but with great difficulty in the right. There was a tendency for the right eye to be kept shut, but even on causing the globes to protrude the red reflex was always seen best in the left pupil. The pupils were of the same size and circular. Iris—slate blue. Ophthalmoscopic examination of both eyes—pale red reflex quite as marked in right as left eye; fundus of a uniform very pale red colour the same in each eye; several blood-vessels pass out in different directions from the optic disc, one of them much larger than the others passes upwards and backwards, another especially large one passes downwards and forwards.

Microscopical Examination. Both eyes. Iris stroma (mesoblast) contains a small quantity of pigment in some parts only; other parts are without pigment; the posterior (epiblastic) layers are deeply pigmented. Epiblastic layer of ciliary body is well pigmented, but with the exception of some pigment in its peripheral part the ciliary body itself (mesoblastic) is free from pigment. Choroid (mesoblast) contains no pigment; retinal epithelium (epiblast) well pigmented. Conjunctiva has no pigment. In view of the difference that was seen in the colour of the two pupils a comparative examination of the retinal epithelium of each eye was made, but no difference could be detected in the depth of pigmentation of this layer in the two eyes whether in stained or unstained sections; nor was there an appreciable difference in the pigmentation of iris and other corresponding parts of each eye.

Case II. Coat—white[1]. Pupils—dark red, the colour made out with difficulty. Iris—slate blue. Ophthalmoscopic examination—fundus in each pale red, paler at periphery than at region of optic disc; appearance and arrangement of blood-vessels similar to that in mouse (Case I).

Microscopical Examination. Right eye. Epiblastic layers of iris darkly pigmented, but stroma has only a small quantity of pigment as in the last case. Ciliary body contains a small quantity of pigment in the stroma; epithelial (epiblastic) layer pigmented. No pigment in choroid; but retinal epithelial layer is pigmented; in ocular conjunctiva no pigment is present; lamina cribrosa is not pigmented.

Case III. Coat—white[2]. Pupils—a red colour made out with difficulty in each. Iris—slate blue. Ophthalmoscopic examination of each—appearance the same as seen in Cases I and II.

Microscopical Examination in right eye. Posterior layers of iris darkly pigmented; stroma of iris contains no pigment. Ciliary body contains no pigment, but its retinal (epiblastic) layer is pigmented. Choroid without pigment, but retinal hexagonal (epiblastic) cells pigmented. No pigment in sclerotic.

Case IV. Coat—white, with small lilac patches on left side of neck, left buttock, round root of tail and on both thighs[3]. Pupils—dark red. Iris—slate blue. Ophthalmoscopic examination—in both eyes fundus has a uniform pale red colour, not patchy, but palest at periphery; optic disc, retinal vessels and refraction same as in the previous cases.

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[1] No granules whatever were found in the hairs of this mouse.

[2] The coats of mice Cases I—III are indistinguishable from that of Case IX, and a breeder of mice informs me that cases like Case I, *i.e.* with dark red pupils, will occasionally occur in mice with parents like Case IX. This point, however, deserves direct and unquestionable investigation. The hairs of this mouse, Case III, contained no granules whatever. K. P.

[3] The coat colour corresponds to No. 41, on the glass mosaic scale of the Biometric Laboratory. The

Microscopical Examination of right eye. Posterior (epiblastic) layer of iris pigmented; stroma unpigmented. Ciliary body unpigmented, but its retinal layer contains pigment. Choroid contains no pigment; hexagonal cells of retina are pigmented. Conjunctiva and sclerotic are unpigmented.

Case V. Coat—piebald, white with lilac patches[1] on saddle, face and rump. Pupils—dark red, easily seen. Iris—slate blue, lighter than in the previous four mice. Ophthalmoscopic examination—appearance of fundus similar to that of mouse (Case I).

Microscopical Examination of both eyes. The pigmentation is the same in each eye; iris pigmented only in its posterior layers, there is no pigment in its stroma; pigment in fundus is confined to the hexagonal cells of retina. In fact the conditions are the same as in the previous cases.

Case VI. Coat—piebald, white with lilac patches on right cheek, left brow and ear, right saddle, both hips and thighs[2]. Pupils—dark red easily seen in right pupil, but feebly marked in left. (Left eye was not quite so prominent as the right.) The pupils dilated after homatropine, and the pale red reflex as seen with the ophthalmoscope was equally marked in each eye. Iris—slate blue, no difference in the two eyes could be detected. Ophthalmoscopic examination—in both eyes fundus of a pale uniform red colour, one not darker than the other.

Microscopical Examination of right eye. Posterior layers of iris darkly pigmented; stroma of iris is not pigmented. In ciliary body only retinal layer pigmented, no pigment in its stroma. Choroid unpigmented; retinal epithelium pigmented.

Case VII. Coat—piebald, all dark lilac except white cheeks; white streak between ears and over left shoulder, and some white on belly and rump[3]. Pupils—dark red reflex readily obtained in left pupil, but in the same light it was doubtful if it was present in the right pupil. On using the ophthalmoscope the pale red reflex in the pupils, dilated with homatropine, was seen as well in one eye as the other. Iris—slate blue. Ophthalmoscopic examination—colour of fundus the same on each side, a pale red; optic disc, retinal vessels and refraction as in the previously recorded mice.

Microscopical Examination of right eye. No pigment in stroma of iris, posterior layers are deeply pigmented. Stroma of ciliary body not pigmented, its retinal

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tint was tested as nearly as possible to the centre of back, where experience has shown that when there is variation in intensity, the darkest tint usually occurs. The white hairs contained no granules, but the others had plenty of granules (δ). The colour of the patches corresponds to the chocolate range of the scale. K. P.

[1] The tint corresponds to No. 47, on the glass mosaic scale of the Biometric Laboratory, *i.e.* lies in pale wild colour. The white hairs had no granules, but there were some in the others (β). K. P.

[2] The tint corresponds to No. 41, on the glass mosaic scale of the Biometric Laboratory, this is in the chocolate range. In some hairs no granules, but in others a decided number (β). K. P.

[3] The tint corresponds to No. 49 of the glass mosaic scale of the Biometric Laboratory, or lies in pale wild colour. In some hairs no granules, in others plenty of granules (δ). K. P.

pigment layer is alone pigmented. No pigment in choroid; retinal pigment layer is pigmented. Conjunctiva, also lamina cribrosa, not pigmented.

Case VIII. Coat—piebald lilac and white[1]. Pupils—dark red. Iris—slate blue. Ophthalmoscopic examination—colour of fundus, blood-vessels etc. similar to last seven cases.

Microscopical Examination of right eye. The pigment is light brown, and is confined to the retinal pigment layers of iris, ciliary body and retina; choroid, stroma of iris and ciliary body contain no pigment.

Case IX. Coat—pure white albino mouse[2]. Pupils—light red. Iris—grey. Ophthalmoscopic examination of both eyes—fundus is much paler than in the mice with dark red pupils (Cases I to VIII), the periphery is nearly quite white; retinal vessels similar to those in the previous cases.

Microscopical Examination of both eyes. There is no pigment in iris, choroid or retina, nor is there pigment in any other part of the eyes.

Case X. Coat—black with small white patch on back and another on belly[3]. Pupils—quite black. Iris—dark brown. Ophthalmoscopic examination—in both eyes the red reflex is much darker than in mice (Cases I to IX), the fundus also is distinctly darker all over.

Microscopical Examination of both eyes. Iris exceedingly darkly pigmented; stroma as well as the uveal (retinal) layers; choroid deeply pigmented; retinal hexagonal cells pigmented; pigment in sclerotic.

Case XI. Coat—dark brown with white belly and several white spots on back[4]. This animal was received dead. It was in 10 per cent. formalin. The corneae were opaque so that the colour of pupils and irides was not observed. The animal was sent, however, as one with dark red pupils[5].

Microscopical Examination of right eye. Posterior layers of iris deeply pigmented; stroma contains some brown pigment but not very much; it forms no continuous layer and is most marked at pupillary end of iris; only retinal layer of ciliary body is pigmented, not the stroma; hexagonal cells of retina pigmented; no pigment in choroid and none in conjunctiva.

Case XII. Coat—light brown[6]. Pupils—black. No ophthalmoscopic examination made and colour of iris not recorded.

Microscopical Examination. Both the stroma and posterior layers of iris are deeply pigmented. Choroid deeply pigmented; retinal hexagonal cells pigmented. No pigment in conjunctiva or cornea, there is some in sclerotic.

Remarks. The pigmentation of the eyes with the dark red pupils (Cases I to VIII), of the eyes of the completely albinotic mouse (Case IX), and of the eyes with black pupils (Case X) was compared in the following way. A piece, consisting of sclerotic, choroid and retinal epithelium, was taken from each eye between the equator and posterior pole and laid on a slide with the epithelium uppermost. In each the retinal epithelium was formed of hexagonal cells which in every case, except the completely albinotic mouse, contained pigment. The pieces were placed in series according to the amount of pigment that appeared to be in the hexagonal cells. The most darkly pigmented piece by far was from one of the mice with black pupils (Cases X and XII). At the other end of the series was, of course, the piece from the completely albinotic mouse. Between the two ends of the series were the pieces from the eyes of the mice with dark red pupils, but there was so very little difference in colour between any of them that they could not be placed in series. Nor could they be placed serially by comparing the retinal epithelium in the sections; for comparison of the microscopical sections of the dark red pupilled mice eyes with those of the black pupilled mice showed that there was no obvious difference in the depth of pigmentation of the retinal pigment layer. When, however, small flakes of the retinal pigment epithelium, detached by brushing, were examined separately, on the flat, a decided difference was noticeable in the depth of the pigmentation between a common wild house mouse and one of the mice with white coat and dark red pupils (Case III), the specimen from the house mouse being the darker.

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[1] The tint corresponds to No. 26 (as nearly as possible) of the glass mosaic scale of the Biometric Laboratory, or lies in pale blue grey. In some hairs no granules, in others a decided number (γ). K. P.

[2] No granules in the hairs.

[3] The tint corresponds to No. 57, on glass mosaic scale of the Biometric Laboratory, or to black. The dark hairs had plenty of granules (δ), the light hairs none. K. P.

[4] The tint corresponds to No. 42, on the glass mosaic scale of the Biometric Laboratory, or to chocolate. The dark hairs had a decided number of granules, some light hairs none. K. P.

[5] The mouse showed such pupils easily before killing and putting in formalin. K. P.

[6] The tint corresponds to No. 40, on glass mosaic scale of the Biometric Laboratory, or lies in the chocolate range. Granules very plentiful in some parts of the hair (ϵ). K. P.

Of the three mice in which the dark red reflex was more readily seen in one pupil than in the other, in two at least (Cases I and VI), that eye in which the red reflex was less readily seen was the less prominent. No difference could be detected in the colouring of the two fundi on ophthalmoscopic examination (Cases I, VI, and VII), or on microscopic examination (Case I), and the pupils were of equal size. When immediately after enucleation the eyeballs (Case VI) were held up together towards a clear evening sky the red reflex was well marked in each pupil.

Conclusion. Mice with white, or piebald lilac and white coats, and dark red pupils, have little or no pigment in the mesoblastic structures of iris, ciliary body and choroid, but the epiblastic layers of iris and choroid (retinal epithelium) are pigmented. The pigment in the hexagonal cells of the retina has a light brown colour; but these cells are not appreciably lighter than those in the corresponding layers of the eyes of mice with black pupils, unless the process of flaking above noted be used.

Mice with black pupils have richly pigmented mesoblastic tissue in iris, choroid and ciliary body, in addition to the pigmented epiblastic layer.

Mice with light red pupils, as far as this investigation extends[1], have no pigment either in the epiblastic or in the mesoblastic tissues of the eye and accordingly are completely albinotic.

In no instance in which pigment was absent from the stroma of the iris was any pigment found in the choroid. The distribution of pigment in the iris of mice with dark red pupils is the same as obtains in the iris of a "wall-eyed" horse, but such mice do not have "wall-eyes" because the iris stroma is so uniformly thin that the pigmented posterior layers show through.

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[1] See, however, the report on Japanese mouse (p. 364) and the second footnote on p. 375.

SECTION VII. *Examination of the Eyes of Guinea-pigs with purple Pupils.*

By C. H. USHER.

Two guinea-pigs with purple pupils and one guinea-pig with black pupils were examined[1]. These three animals belong to a kind sometimes called "Japanese" and known to the dealers as "Agoutis." After noting the colour of the pupils, the iris, and the coat, a mydriatic was used to each eye, and an ophthalmoscopic examination made when the pupils had dilated. The animals were killed with chloroform and immediately after death the enucleated eyeballs were placed in 5 per cent. formalin. Half of each eyeball was embedded in celloidin after opening antero-posteriorly, parts of the rest of the eyes were embedded in paraffin. Some sections were stained with haematoxylin, or eosin, or both, others were examined unstained.

Case I. A male with thick, uniformly light yellow-brown fur[2], belly nearly white with a light yellow tinge. Whiskers—some of the hairs are brown, others are nearly white. Iris has a uniform grey-brown colour. Pupils have a marked deep purple-red colour, equally obvious in both. Ophthalmoscopic examination—right eye has a very pale fundus; choroidal vessels are sharply defined, the fundus is white between them; optic disc is of a uniform bluish white colour, no blood-vessels are seen on it or in the retina[3], around it is an area with a stippled appearance: left eye less satisfactory to examine owing to conjunctivitis, but there is no doubt that the choroid has the same light character as in the right eye and that the optic disc presents a similar appearance. The refraction was estimated to be emmetropic in each eye. No nystagmus. On opening the eyeballs the iris and ciliary body were seen to be much darker than the choroid. Choroid contains light brown pigment, which is quite obvious to the naked eye, and the blood-vessels are now lighter in colour than the parts between them. There is no patchiness in the pigmentation of the fundus or iris.

Microscopical Examination. 1. Retinal epithelium examined on the flat consisted of pigmented hexagonal cells. 2. The sections show that the retinal pigment layer has a light brown colour. Choroid contains pigment but not a great deal; its blood-vessels are conspicuous. Ciliary body is lightly pigmented as regards its stroma, the retinal layer, however, is quite well pigmented. Iris stroma is lightly pigmented throughout, the pigment being contained in branched cells; the retinal layers are pigmented. The ligamentum pectinatum is pigmented. At the limbus there is a small quantity of pigment in the deepest layer of the conjunctival epithelium, the other parts of the cornea and conjunctiva are unpigmented. The sclerotic contains a small quantity of pigment in its superficial layers and in a few places a little brownish pigment is seen in the deeper layers.

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[1] Kindly sent by Dr John C. G. Ledingham.

[2] The tint on the glass mosaic scale of the Biometric Laboratory was No. 46. It corresponds to pale wild colour on the scale for mice. Parts of the same hair have no granules, other parts plenty (δ). K. P.

[3] This absence of visible retinal vessels is a normal condition in many of the lower mammals, the common guinea-pig and the Agoutis being well-marked instances.

Case II. A male with thick deep snuff-brown uniform fur[1], rather lighter on the belly; dark whiskers. Iris grey-brown. Pupils have a marked deep purple-red colour, more conspicuous than in guinea-pig, Case I. This animal had a much wider palpebral fissure and in consequence the eyes were more exposed than those of guinea-pig Case I, which had conjunctivitis. After homatropin, with equally dilated pupils, the same result was obtained. Ophthalmoscopic examination—R. and L. eyes: the fundus is pale yellowish white; the choroidal vessels are conspicuous. No pigment is seen between the vessels. On comparing this fundus with that of the previous animal it cannot be said that one is lighter than the other. The optic disc has a uniformly blue-white colour except at the centre where it is whiter. Around the optic disc at the lower and anterior part is a stippled area. Refraction emmetropic. No nystagmus. On opening the eyeballs the iris and ciliary body were seen to be much darker than the choroid; no patchiness in pigmentation of any of these structures. Choroid contains light brown pigment. The choroid, and probably the retinal pigment cells also, are more darkly pigmented than in guinea-pig, Case I, to judge by the lighter appearance of the choroidal vessels in that case.

Microscopical Examination. 1. When seen on the flat the cells of the retinal pigment layer were hexagonal and pigmented more deeply than those in guinea-pig, Case I. 2. Pigment in the eyes of this animal is distributed as in guinea-pig, Case I, and in the sections no difference in the degree of pigmentation can be made out.

Case III. A male with dark brown fur[2]. Iris brown. Pupils quite black. Ophthalmoscopic examination—fundus much darker than those of Cases I and II. The choroidal vessels are not conspicuous, being visible only here and there. The optic disc has the same appearance as in the other two guinea-pigs. Refraction emmetropic. On opening the eyeballs the fundus is seen to be quite dark.

Microscopical Examination. 1. Retinal epithelium examined on the flat is much more deeply pigmented than in the other cases; seen in section this layer is less darkly pigmented than the choroid upon which it lies, the latter being deeply coloured. The stroma of iris and ciliary body also contains much pigment which is situated in branched cells; and the retinal layers of these parts are also deeply pigmented. Ligamentum pectinatum is well pigmented. The sclerotic is pigmented, there is a distinct layer of pigment in the superficial layers and also much pigment at some parts of the deeper layers. The deep layer of epithelium at the limbus conjunctivae is markedly pigmented. The other parts of the cornea and conjunctiva are unpigmented.

On comparing the eyes of the black-pupilled guinea-pig (Case III) with those of the guinea-pigs with purple pupils (Cases I and II) it is obvious that in the former the choroid, sclerotic, stroma of iris and ciliary body are more pigmented than in the latter. The pigmentation of the cells of the epithelium at the limbus cornea is darker in the black-pupilled guinea-pig than in the purple-pupilled ones. The retinal epithelial layers of iris, ciliary body and retina appear also to be more pigmented in the black-pupilled than in the purple-pupilled eyes.

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[1] The nearest tint on the glass mosaic scale of the Biometric Laboratory was No. 49, but the match was not a good one: it belongs again to pale wild mouse colour. Parts of the same hair were without granules, others with plenty (δ). K. P.

[2] The tint corresponded to No. 55 of the glass mosaic scale of the Biometric Laboratory, or near to the black range. Parts of the same hair have no granules, other parts with plenty of granules (δ). K. P.

SECTION VIII. *Examination of the Eyes of completely and incompletely Albinotic Birds.*

By C. H. USHER.

Albinotic birds.—With the intention of comparing the degree of pigmentation in the eyes of albinotic birds and of the corresponding normal birds, and of ascertaining whether mesoblastic or epiblastic tissues were involved in any existing deviation, some specimens of completely and of incompletely albinotic birds' eyes were obtained for examination. The following is the list of albinotic birds whose eyes were examined. Those birds marked with an asterisk were seen only during life, the eyes of the others were examined microscopically.

Number examined		Name of bird	Number examined		Name of bird
A. 2	Black Grouse	(*Tetrao tetrix*)	K.* 1	Skylark	(*Alauda arvensis*)
B. 1	Red Grouse	(*Tetrao scoticus*)	L. 1	Skylark	(*Alauda arvensis*)
C. 2	Partridges	(*Perdix cinerea*)	M. 1	Lapwing	(*Vanellus vulgaris*)
D. 1	Pheasant	(*Phasianus colchicus*)	N. 1	Yellowammer	(*Emberiza citrinella*)
E. 1	Blackbird	(*Turdus merula*)	O. 2	Canaries	(*Fringilla canaria*, Linnaeus)
F.* 4	Blackbirds	(*Turdus merula*)			
G.* 1	Thrush	(*Turdus musicus*)	P. 1	Twite	(*Fringilla flavirostris*)
H. 3	Jackdaws	(*Corvus monedula*)	Q. 4	Canary-redpoll Hybrids	
I. 3	Rooks	(*Corvus frugilegus*)	R. 1	Sparrow	(*Passer domesticus*)
J. 2	Wood Pigeon	(*Columba palumbus*)	S.* 1	Sparrow	(*Passer domesticus*)

In considering the pigmentation of the bird's eye there has to be taken into account a structure not present in mammals, namely, the pecten, which is a markedly pigmented vascular body arising from the fundus at the optic disc and projecting far forwards into the vitreous. In the bird's eye there is also in the anterior part of the sclerotic a bony ring and much of the sclerotic is occupied by cartilage. The iris contains numerous muscle fibres which may influence in some measure the distribution of the stroma pigment. The stroma pigment of the iris is situated to a large extent at its anterior part. Leuckart[1] says that birds with yellow colour of iris have fat cells of remarkable size. The microscopical sections of our birds' eyes were cut after embedding in celloidin.

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[1] Leuckart, "Organologie des Auges," *Handbuch der gesammten Augenheilkunde*, von Graefe-Saemisch, I. Aufl. II. Bd. 2 Tl. 1876. S. 237.

A (i). *White Blackcock* (*Tetrao tetrix*). This bird was shot in Selkirkshire on 29 October, 1908[1]. The complete bird was received on 2 November. It was in excellent condition; weight = 2 lbs.; measurement from tip of beak to tail tip = $16\frac{1}{2}''$; girth round wings = 13″; spread of outstretched wings = $26\frac{1}{2}''$; its shape of body and half-grown tail just like a normal blackcock; beak dark, but not quite black; when held up by lower part of beak weight of body did not fracture it; crop full of corn, heather and clover. The *feathers* are of a nearly uniform light grey; on neck and rump are some light red-brown feathers; edge of eyelids darkly pigmented. *Eyes*: corneae opaque and collapsed, iris not visible in consequence. Viewed from behind after enucleation both eyes were dark. Nictitating membrane had light brown pigment bands. The corresponding bands in a normal grey hen (female of the blackcock) were very dark. Iris examined in front after removal of cornea was brown. Eyeball was opened equatorially. Fundus and pecten were brown. Compared with the normal grey hen the iris, fundus and pecten had a lighter brown colour.

Microscopical Examination. Nictitating membrane contains pigment at its free margin. The pigment at this part is limited to the epithelium on the anterior surface of the membrane. At the pigment band next to the free margin—the second pigment band—there is pigment in the stroma and only a few very small pigment particles in the anterior epithelium. In the membrane still further from its free margin are small isolated collections of pigment at intervals situated in the stroma at a distance from either surface; no pigment in the epithelium. Iris is pigmented in retinal layers and stroma. The choroid and pecten were less pigmented than those of a normal grey hen; but the retinal pigment layer if at all lighter than that in the normal bird is only very slightly so.

A (ii). *White Grey Hen*[2] (*Tetrao tetrix*). This bird was shot in Selkirkshire on 10 September, 1908. It was smaller than the rest of the covey and its feathers were described as being nearly white. The head and neck were received on 14 September. The *feathers* are light grey but darker than in the previous bird. Eyelids grey with a narrow dark margin. Beak dark brown. *Eyes*: corneae opaque, but irides are visible and have rather a light brown colour. Nictitating membranes have a narrow line of pigment at their free margins, and a second band of brown pigment at some distance from the margin. The eyes are dark when viewed from behind after enucleation. An eyeball was opened equatorially after hardening for four weeks in 5 per cent. formalin. The fundus and pecten were pigmented apparently as deeply as in a normal grey hen's fundus examined for comparison. But the pigment bands on the nictitating membrane were much lighter than those of three normal grey hens with which they were compared.

Microscopical Examination. Nictitating membrane contains pigment in the anterior epithelium at its free margin. The pigment at the pigmented band next to this is contained both in the anterior epithelium and in the stroma, still further from the free margin are small collections of pigment situated in the stroma as in the normal grey hen. Iris is pigmented in stroma and epithelial layers; the stroma, however, contains only a small quantity of pigment and this lies in cells far forward, forming anteriorly a continuous layer of pigment. Pecten is lightly pigmented; choroid pigmented. The arrangement of the pigment in these structures is the same as in the normal grey hen, but there is less pigmentation of the iris stroma, pecten and choroid.

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[1] See Plate KK (117) and (119) for a photograph of this bird and a normal bird.

[2] See Plate KK (118) and (120) for a photograph of the head of this bird and one of a normal bird.

Normal Grey Hen. The eye, in 5 per cent. formalin, received 8 October, 1908, was opened in same manner as the eyes of the white blackcock and white grey hen. The result of a naked eye comparison of the pigmentation with that of the white birds is given in their notes.

Microscopical Examination. Fundus—the pecten contains much coarse brown pigment; in the retinal epithelium is brown pigment, considerably lighter than the dark pigment in choroid; near the sclerotic choroidal pigment is not so dark and is arranged in long pieces which lie parallel to the cartilage behind it; nearer retina the dark pigment forms circles round the blood-vessels. Some pigment on the sclerotic. Iris has deeply pigmented retinal layers. Anterior part of iris is darkly pigmented, from it pigment extends into the stroma; but the greater part of iris stroma is unpigmented. Ciliary body has darkly pigmented retinal layer; the pigment in stroma is arranged in long pieces lying parallel to the sclerotic. The nictitating membrane is pigmented at three places, (i) its free margin with pigment limited to the epithelial cells of the anterior surface, (ii) the second pigment band with pigment in the stroma and the epithelial cells of the anterior surface, (iii) pigment bands further from the free margin with pigment limited to the stroma. The arrangement of the pigment in the nictitating membrane from another grey hen was found to be the same, but in a normal blackcock it differed in that the second pigment band had only exceedingly few minute particles of pigment in the epithelium; its stroma was pigmented.

Remarks. It was stated that the two white birds belonged to the same covey. Two or three years ago a white grey hen was shot in the same locality, so there is a possibility that the three birds belonged to the same stock.

From the examination of the present two birds and the comparison with a normal bird it appears that the white birds have less than the normal pigment in their eyes. With the naked eye this was apparent in both birds as regards the nictitating membrane, and in the white blackcock the iris, fundus and pecten were lighter than those of the normal bird, also microscopically the iris, fundus, and especially the pecten were more lightly pigmented in the white grey hen than in the normal bird and the nictitating membrane was more lightly pigmented in both than in the normal bird. Yet the difference is not very great and age may partly account for it.

At the same place where these two incompletely albinotic birds came from in the autumn of 1908, there was in July, 1910, a covey of black-game with two white birds in it. An old gentleman living in the neighbourhood states that there have been white black-game in the same place for many years past. A letter in the *Scotsman* 1 April, 1911, from J. B. B. states that between Selkirk and Ettrick on

26 March, 1911, a white bird was observed feeding among some black-game. This is the same district from which our albino black-game came. The bird resembled a blackcock in size and those who noticed it wondered if it were possibly an albino blackcock. In the *Times*, 1 December, 1908, the following paragraph appeared:

> *A Partial Albino Blackcock.*—Examples of Albinism appear to be rare in the blackcock, very few instances being on record. Mr Rowland Ward has recently mounted for Mr Dalrymple Hamilton an interesting partial albino obtained at Dailly, Ayrshire. The head, neck, and upper surface were practically normal, but the tail coverts, some of the wing coverts, and a few feathers on the neck were white. From the lower neck was a broad band, widening on the abdomen and extended to the thighs; here the plumage was preponderantly white, though some of the feathers were edged with black. The extent of white on the bird was much greater than on the specimen figured by Mr J. G. Millais in his *Game Birds* as presenting the most advanced instance of albinism in this species known to him.

Permission was kindly given to C. H. Usher to examine the black-game in the Rothschild Museum at Tring, where in addition to the albinotic grey hen with brown iris and a plumage "white with grey tinge" (see our list of albinotic birds with note of eye colour in the following chapter) there is a very large number of "varieties" of black-game in which the eye colour is not recorded. When the skins of these birds are seen side by side it is at once evident that they can be readily separated into several groups according to the colouring of the plumage[1].

1. A large group in which the plumage generally is normal but with a number of abnormal white feathers, numerous in some birds, scanty in others. None of the specimens are completely white or indeed nearly all white.

2. A light grey or light slate-coloured blackcock. There is only one specimen. The colour is nearly uniform and none of the other birds are at all like it. The colour resembles that of our jackdaws (p. 388) and blackcock (Plate KK (117)).

3. Blackcocks of uniform brown colour—several specimens.

4. Grey hens with plumage very uniformly pale brown—some twenty specimens of this sort. The brown colour is much lighter in shade than that of the blackcocks in Group 3. It will thus be seen that colour variation is by no means rare in *Tetrao tetrix.*

B. *Red Grouse* (*Tetrao scoticus*). This bird was reported to be lighter all over than a normal grouse and there was much grey together with white about it. It was obtained in Sutherlandshire. The eyes were received in 10 per cent. formalin 7 October 1910.

Eyes: macroscopically iris dark; fundus and pecten dark. *Microscopical Examination*: limbus has dark pigment in its epithelium; dark pigment at sclero-corneal margin, chiefly at insertion of ligamentum pectinatum; in some sections pigment is continued forwards to anterior part of sclero-corneal junction, but no pigment present in loose tissue beneath the anterior epithelium or in tissue external to the bony plate. Ciliary body has a dark epiblastic layer and much dark pigment in its mesoblastic portions; iris has dark posterior layers; branched pigmented dark cells in stroma chiefly in the form of a dark band at anterior part of iris which is composed of closely packed branched cells; some branched pigmented cells are beneath this layer, but usually close to it; at pupil region these chromatophores occupy the whole thickness of the sections. Retinal pigment layer is well pigmented; choroid has continuous layer of pigment next sclerotic; around the large blood-vessels the dark choroidal pigment is arranged concentrically. Pecten very deeply pigmented. On outer surface of sclerotic there is in some places a continuous pigment layer.

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[1] 1. = Frauenfeld's *allochroism*; 2. = his *chlorochroism*; 3. and 4. = his *synchroism*: see our footnote p. 10.

A snowy white grouse with a few dark feathers in the tail and wings was shot some years ago with two ordinary grouse on the moors at Dunrobin. "It was not an albino; I think the eyes were dark[1]."

The iris of the normal red grouse is chestnut brown: see footnote p. 387.

C (i). *Cream-coloured Partridge* (*Perdix cinerea*). Colour of plumage reported as uniform, with darker markings faintly indicated. Eyes were not pink. Killed in Inverness-shire. Eyes received 18 April, 1911, in 10 per cent. formalin. Nictitating membrane has a dark edge. The external appearance of the whole of the eye is dark; iris dark brown; fundus very dark, uniformly so; pecten pale brown with darker crest. *Microscopical Examination*: much pigment at sclero-corneal junction; iris posterior layers darkly pigmented; stroma at anterior surface of iris forms a continuous very dark band; pigment present in other parts of iris stroma, principally near pupil; ciliary body well pigmented in mesoblastic and epiblastic portions; choroid darkly pigmented; continuous dark lamina fusca; on outer surface of sclerotic a continuous layer of pigment; limbus pigment is mostly beneath the anterior epithelium, but a small quantity is in the epithelium; sclero-corneal junction is pigmented in its entire thickness; pecten full of pigment; nictitating membrane at free edge has much pigment in epithelium, in other parts of it the pigment is in stroma.

In comparison with a normal partridge the distribution and quantity of the eye pigment appear to be the same.

C (ii). *Incomplete albino Partridge* (*Perdix cinerea*). "Eyes from a partridge, nearly white, from Fife" received in formalin, 1 October, 1909. *Macroscopical Examination*: no pigment at limbus; free edge of nictitating membrane darkly pigmented; a second band of pigment near free edge; iris very dark brown; ciliary body and fundus dark; pecten pigmented. *Microscopical Examination*: very scanty pigment in epithelium at limbus; marked pigmentation of sclero-corneal junction especially in posterior layers; iris epiblastic layers dark; stroma darkly pigmented at anterior surface forming continuous layer of dark pigment; dark branched pigmented cells mostly found in pupillary part of iris, absent in some sections; retinal pigment layer contains brown pigment; pecten pigmented throughout by groups of small brown circular grains, crest as usual is darkest part; choroid well pigmented, most of it is black, at a few places brown is distinguishable; continuous layer of brown pigment next to sclerotic.

Normal partridge with plumage of a well-grown young bird, received from Roxburghshire, 29 October, 1909. *Macroscopical Examination*: nictitating membrane with darkly pigmented edge and second pigment band near edge; limbus unpigmented; iris black; fundus black; pecten very dark brown, black at crest; ciliary body and iris black when viewed from behind. *Microscopical Examination*: some pigment in anterior epithelium at limbus, very scanty subepithelial pigment; dark pigment in deep layers at sclero-corneal junction; iris posterior layers very dark brown, nearly black; stroma well pigmented, anterior parts very dark brown, quite as dark as posterior parts; retinal pigment layer and choroid very darkly pigmented; pecten darkly pigmented especially at crest.

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[1] Fayrer, J., *Nature*, Vol. XVIII. p. 518, 1878.

In no part of the eye is there much difference in the depth of pigmentation in the two birds. To the naked eye the albino iris was lighter than that of the normal bird, but it is difficult to be certain that, as seen with the microscope, there is less pigment either in stroma or posterior layers. The fundus and ciliary body of both birds are equally dark on macroscopic examination and there is probably little if any difference in their pigmentation. The pecten contains less pigment in the albino, this corresponds with the lighter appearance presented to the naked eye.

D. *White Pheasant* (*Phasianus colchicus*) with "pink-eyes" and "not a dark feather on it," from Nairnshire.

Eyes, received 18 April, 1911, in 10 per cent. formalin, were not in good condition. There was no pigment on nictitating membrane or on front of eyeball; iris grey; pecten dark; fundus brownish with darker parts (appearance evidently due to detached portions of retinal pigment). *Microscopically* no pigment found in nictitating membrane; iris and ciliary body have no stroma pigment, epiblastic layers appear to have been well pigmented, but have largely become separated owing to unsatisfactory condition of the specimen; choroid has no pigment; retinal pigment layer dark with brown pigment; pecten has much pigment especially at crest; no pigment at limbus or in sclerotic.

The normal pheasant has a yellowish orange coloured iris with tinge of brown.

E. *Blackbird* (*Turdus merula*). This bird was reported as pied. Eyes received 7 October, 1910, in 10 per cent. formalin. Macroscopically iris is dark; lens dislocated backwards when eye was opened equatorially and a ring of dark pigment was left on its anterior surface; pecten and fundus dark. *Microscopical Examination*: no pigment at limbus; at posterior part of sclero-corneal junction is a quantity of dark pigment; ciliary body has not much stroma pigment, but a dark epiblastic layer; iris has dark posterior layers and much dark brown pigment in branched cells in most parts of stroma though principally at anterior part of iris; retinal pigment layer uniformly dark; choroid is unpigmented at optic disc; on tracing sections from the optic disc pigment appears first in lamina fusca at irregular intervals (and this at a considerable distance from optic disc), still further away from the optic disc the pigment becomes continuous in this layer and pigment appears in choroid, as usual, round the blood-vessels; pecten darkly pigmented, darkest at crest; no pigment found in sclerotic[1].

The absence of pigment from choroid at region of optic disc and pecten would appear to favour the view of the epiblastic origin of the pigment in the pecten, for if the pecten pigment is in mesoblastic tissue it is isolated in this case by unpigmented mesoblastic tissue (choroid) from the pigmented portions of the mesoblastic choroid. The iris of a normal blackbird is dark brown[1].

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[1] In a normal blackbird the choroidal pigment was found to extend as far as the optic disc, and the limbus corneae was pigmented. There was no difference in depth of pigmentation of the epiblastic pigment layers and the pecten of the pied and normal bird.

F (i). *Complete albino Blackbird* (*Turdus merula*). A living specimen belonging to Dr A. Rudolf Galloway. History—age about 2½ years; hatched in a nest near Portsmouth; other two birds in the nest of which one was normal and the other pied. It is probably a female. Plumage all pure white; beak markedly yellow; legs and toes pink; yellow colour at margin of eyelids forms a marked yellow ring round the eye; iris is grey and translucent with red showing through; pupil very red; no pigment seen at pupil edge on magnification with pocket lens; on ophthalmoscopic examination fundus is white where seen in the intervals between well defined choroidal vessels; optic disc and pecten not made out; refraction: retinoscopy showed myopic shadows. From an examination of this bird's eyes during life the presence of pigment would certainly not be suspected, yet until they are examined with the microscope it cannot be stated that they are pigmentless.

F (ii). *Complete albino Blackbird* (*Turdus merula*). A quite white cock bird with yellow beak and grey legs, hatched in Peeblesshire, seen in cage, 14 September, 1909. Eyes: iris grey and translucent; red pupils; no nystagmus; lids yellowish. The history is that both parents were ordinary blackbirds. In April 1905 four young white blackbirds were found in a nest on a tree. The young birds were taken from the nest and they all died. In May of the same year two white and two ordinary coloured blackbirds were reared in the same nest. The present bird is one of the two white ones. The other white one of the second brood died after a few months in captivity. The eggs were never seen.

F (iii). *Complete albino Blackbird.* A young bird with white feathers, yellow beak and yellowish legs, seen in cage 1 January, 1910. Eyes: iris grey and translucent, marked red reflex in pupil; no nystagmus. The owner has kindly written to say "I can't give you any information regarding his ancestors. He was caught wild when apparently five or six weeks old about two miles south of Edinburgh and presumably the parents were black as no white or pied specimens had been seen about."

F (iv). *Complete albino Blackbird.* Feathers white; bill yellow and legs yellowish, seen in cage on 1 January, 1910. Eyes: iris grey and translucent; marked red reflex in pupil; no nystagmus.

No coloured feathers were present in any of these four birds, no pigment was seen in the iris, which in each case was very translucent, and the red reflex in pupil was easily obtained, therefore, in the absence of microscopical proof, there is reason for believing that all these eyes were devoid of pigment. On the other hand, the presence of pigment in the white sparrow (p. 397) and yellow-ammer (p. 394) which had apparently equally albinotic eyes makes it less likely that such eyes as those of the four blackbirds have no pigment.

G. *Complete albino Thrush* (*Turdus musicus*), seen in captivity, 15 September,

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[1] Eyes of normal blackbird, wood-pigeon, yellowammer, sparrow and red grouse were examined and found to have well-pigmented epiblastic layers of iris and ciliary body; retinal pigment layer and pecten were darkly pigmented as well as choroid, stroma of iris and ciliary body.

1910, bill and legs pale yellow. Age 18 months. Pupil has a marked red reflex; iris is grey and very translucent; lids yellow; vision as tested with meal worms seemed defective in bright light (sunshine), but not in moderate light. The parent birds were of normal colour and so were the other young ones in the nest. From the colour of its plumage and eyes this living bird would be grouped with the four blackbirds, and the remarks as to the possible presence of pigment in the blackbird's eyes apply equally to this bird.

The normal thrush's iris is dark chestnut brown.

H (i). *Incomplete albino Jackdaw* (*Corvus monedula*) from Kent, hatched in April 1909, examined 18 January, 1910. Feathers pale grey; beak and legs pinkish; call that of the jackdaw. Eyes: iris grey-blue; pupil black with occasional tinge of deep red in certain lights. Died 7 June, 1910. After enucleation the pupil became red with transmitted light; no pigment on nictitating membrane or at limbus; iris blue-grey with dark margin at pupil, viewed from behind iris is light brown (eye opened equatorially) and when held towards the light much more light was transmitted than by the iris of normal bird held in the same way; the former appears very light, the latter quite dark; fundus brown; pecten quite dark. *Microscopical Examination*: no pigment in nictitating membrane, at limbus, sclero-corneal junction, pectinate ligament or external to bony plate; iris stroma pigmentless; dark posterior layers; ciliary body stroma has no pigment; dark epiblastic layer; no trace of pigment in choroid; retinal pigment layer and pecten darkly pigmented.

H (ii). *Incomplete albino Jackdaw* from Tyrol, age 20 months, examined 4 February, 1910. Feathers very light grey; beak dark grey; legs grey with yellowish tinge; its call that of a normal jackdaw. Eyes: iris blue; pupil most often black although in favourable light it is distinctly red. This bird was bred in captivity; no information could be obtained as regards the parent birds; it died 10 August, 1910. Eyes: limbus and nictitating membrane without pigment; iris pale blue-grey; red reflex in pupil both by reflected and by transmitted light; fundus extremely light, possibly contains no pigment; pecten brown, ciliary body darker than fundus. *Microscopical Examination*: nictitating membrane has no pigment either in epithelium or stroma; limbus quite pigmentless; no pigment at sclero-corneal junction; iris has darkly pigmented posterior layers but no stroma pigment; ciliary body has no stroma pigment; a dark epiblastic layer; pecten well pigmented; retinal epithelium with deep brown pigment; no pigment in any part of choroid.

H (iii). *Incomplete albino Jackdaw*. This bird is from same nest as No. (i); no other bird was in nest; parent birds normal jackdaws. "White jackdaws" we are told have been obtained from the same place for several years. Examined 4 February, 1910. Plumage even lighter grey than that of No. (i); beak white; legs pinkish. Eyes: iris grey-blue; red reflex obtained with difficulty in pupil; it died 7 March, 1910. Nictitating membrane and limbus pigmentless; iris grey-blue with darker ring at pupil; fundus pale; ciliary body much darker than fundus; pecten pigmented. *Microscopical Examination*: no pigment at limbus or in nictitating membrane and none at sclero-corneal junction; posterior layers of iris dark brown, stroma without pigment; choroid pigmentless, so is sclerotic; brown pigment in retinal pigment layer; brown pigment in pecten in form of small round pieces most numerous at crest.

Normal Jackdaw killed with chloroform 31 May, 1910. Eyes placed in formalin. Plumage as usual generally black with grey feathers on head and neck. Eyes: pigment at free margin of nictitating membrane; iris white with marked black ring at pupil margin; complete dark circle of pigment at limbus; no red reflex in pupil by transmitted light when eye is held towards window; fundus black; pecten dark brown with black crest and nearly white base; ciliary body very dark. *Microscopical Examination*: nictitating membrane has pigmented epithelium and stroma; at limbus deep layers of anterior epithelium darkly pigmented and pigment in subepithelial tissue; much dark pigment at junction of ligamentum pectinatum and cornea; dark pigment at outer surface of bone plate; iris stroma dense, not pigmented, posterior layers dark; in ciliary body dark brown branched stroma cells and deeply pigmented epiblastic layer; retinal pigment layer dark brown; pecten well pigmented; choroid continuous dark brown layer next sclerotic, throughout choroid pigment is in dark masses, darker than the retinal pigment layer.

On comparing the results of the examination of the pigmentation in the eye of the three incomplete jackdaws with those of the normal jackdaw the following points may be noted:

(1) The anterior part of the eye is pigmentless in the albino birds whilst in the normal bird pigment is found at limbus in the epithelium and subepithelial tissues, external to the plate of bone and at deep parts of sclero-corneal junction.

(2) The nictitating membrane is pigmentless in the three birds; in normal bird there is pigment in the epithelium and stroma.

(3) The epiblastic pigment layers of iris, ciliary body and retina are equally dark in all of the birds.

(4) Neither normal nor albinotic birds have pigment in iris stroma.

(5) The stroma of ciliary body and the choroid are well pigmented in the normal bird; none of the albino birds have pigment in these structures.

(6) The fundus is much lighter in the albino birds than in the normal, accounted for by absence of choroid pigment.

(7) Iris is white in normal bird and blue grey in albino bird; much more light is transmitted by the albino iris than by the normal iris, although the epiblastic layers are equally pigmented and there is no pigment in stroma of either bird. The explanation of this difference appears to be the denser stroma in the normal bird.

(8) The pecten is quite well pigmented in the albinotic birds. As in these birds there is absence of pigment in iris and ciliary body stroma, and in choroid, but pigment is present in epiblastic layers, the pigment of the pecten may also be confined to epiblastic tissues.

I (i). *Albino Rook* (*Corvus frugilegus*), a young bird, shot in Aberdeenshire, 19 May, 1911. Plumage nearly uniformly cream-coloured, posterior part of body is more nearly a dirty white; darkest parts are the secondaries; bill pinkish; feet normal, were pinkish, now more yellow; feathers on bill. Eyes preserved in 10 per cent. formalin appear to be quite pigmentless; red seen in pupil; iris translucent, scarcely visible, is faintly grey; nictitating membrane has no pigment; after opening the eyeball fundus looks pale pink, pecten rather darker than fundus, and it has a faint brown tinge; vessels in it visible; lens in one eye dislocated backwards and at its equator was a pale brown band of pigment, the anterior part of it was serrated and darker than the posterior portions. *Microscopical Examination*: iris contains no stroma pigment, brown pigment present in posterior layers, which have largely adhered to lens; no pigment in stroma of ciliary body, brown pigment in epiblastic layer, also adherent to lens; choroid pigmentless; retinal hexagonal cells nearly pigmentless, a brown tinge made out in the retinal portion of the cells, none in the choroidal; pecten also almost pigmentless, with oil immersion lens, however, brown granules are evident in a number of cells at the crest; no pigment at limbus. The pigment in this bird's eyes is confined to the epiblastic layers—unless that in pecten is mesoblastic—where it is exceedingly scanty. It is in greatest quantity in iris and ciliary body, though much diminished even in these places.

I (ii). *Albino Rook* (*Corvus frugilegus*) killed near Lincoln at end of May, 1911. It is described as cream-coloured, totally so, not in the least pied, or otherwise coloured; legs the same colour as the feathers. Eyes were received in 10 per cent. formalin. They were much collapsed and not translucent on 12 June. On opening the eyes, the lenses dislocated and showed a pale brown circle on anterior surfaces, similar to what was seen in the albino Rook (i) (p. 389); no pigment seen in anterior part of eyes; doubtful if any in posterior part; eyes in bad condition. *Microscopical Examination*: no pigment in iris stroma; posterior layers adherent to lens are not darkly pigmented; ciliary body has lightly pigmented epiblastic layer; no pigment in choroid; hexagonal cells of retina almost pigmentless, just the faintest tinge of brown is seen in the distal (part next retina) portion of the cells; pigment absent at optic nerve entrance and at sclero-corneal junction; pecten not present in sections examined, it may possibly have become loosened and washed off in preparation in consequence of bad condition of eye.

I (iii). *Pied Rook* (*Corvus frugilegus*) with much white about it and "feet half white." Head and neck received 10 May, 1910, from Oxford. Feathers on head and neck black except below beak where they are quite white. This white patch extends backwards on each side to posterior part of lower lid; upper eyelids covered by black feathers only; beak pale, for most part yellow, bluish towards tip, it is soft; almost certainly a young bird; upper part of beak well feathered with black feathers on left side, except the most posterior ones which are white and continuous with the white feathers which are more numerous on right side of beak; sharp curved tip to beak. Eyes: nictitating membrane unpigmented; dark grey complete ring at limbus; iris blue-grey, bluish near pupil; brown ring at pupil margin; fundus dark; pecten dark with broad pale base. *Microscopical Examination*: iris epiblastic layers very dark; no pigment in stroma; ciliary body epiblastic layer well pigmented; stroma is unevenly pigmented, much more pigment in one section than another and sometimes much more at one side in the same section; no pigment in choroid; pecten scantily pigmented; retinal epithelium well pigmented; limbus lightly pigmented in epithelium and subepithelial tissue.

Normal Rook (*Corvus frugilegus*), old bird received 8 June, 1910, from Aberdeenshire. Examined only macroscopically. Iris is very dark brown, quite different from the light grey iris of the pied rook which resembles that of the jackdaw. Fundus is dark. Pecten distinctly brown with a yellow-white base. Edge of nictitating membrane well pigmented; at a short distance from edge is a broader brown band. Dark pigment at limbus. A second normal specimen, an old black rook, has eyes macroscopically similar to the first specimen, namely, dark brown iris, ciliary body and fundus; pecten dark brown with pale yellow base; nictitating membrane with brown edge and a second brown band at a short distance from free edge; limbus very dark. *Microscopical Examination*: iris has dark posterior layers and stroma well pigmented with dark brown pigment, which is most abundant at anterior part; ciliary body darkly pigmented in stroma and epiblastic layer; retinal pigment layer has dark brown pigment; choroid with very dark pigment round blood-vessels; pecten well pigmented, crest much more pigmented than other parts; limbus pigment is in anterior epithelium and in subepithelial tissue; dark pigment is present at posterior part of sclero-corneal junction.

The blue-grey colour of the pied rook's iris, so very different in appearance from the dark brown iris of the normal bird, is accounted for by absence of stroma pigment. The pied rook has pigmented stroma in ciliary body, though no pigment in iris stroma or choroid, whilst the normal rook has pigment in all these situations; limbus of the pied bird is less pigmented than that of the normal bird. The difference in pigmentation between the two cream-coloured rooks' eyes and the normal rook's eyes is greater than that between the pied and normal birds' eyes, for in the cream-coloured rooks there is complete absence of mesoblastic pigment in the eye and marked deficiency of epiblastic pigment.

The microscopical appearances of the pigmentation of a normal crow's (*Corvus corone*) eye were similar to those of the normal rook's eye.

J (i). *Incomplete albino Wood-pigeon* (*Columba palumbus*), from Forfarshire, with much white all over it; head is white and the dark feathers generally are lighter than normal; bill and feet dark. Killed 3 February, 1910. Eyes preserved in 7 per cent. formalin. *Macroscopically*: iris light grey with dark pupil margin; fundus moderately dark brown; pecten light brown with darker crest. *Microscopically*: iris has darkly pigmented posterior layers and pigmented chromatophores which are most numerous in anterior part of iris; subepithelial pigment at limbus which extends backwards external to bony plate; large deposit of light brown pigment at deep part of sclero-corneal junction (insertion of ligamentum pectinatum); ciliary body has well pigmented stroma and epiblastic layer; retinal pigment layer uniformly dark brown; choroid has much pigment around the blood-vessels; continuous dark lamina fusca; pecten darkly pigmented.

The iris of a normal wood-pigeon is pale yellow: see footnote p. 387.

J (ii). *Pure white Wood-pigeon* (*Columba palumbus*). In Dr Galloway's collection. Plumage quite white, not a single dark feather—a gamekeeper who saw the bird three minutes after it was shot examined the pupil particularly and found it was black. He knew this bird's nest and saw its two young ones which were like ordinary wood-pigeons.

An eye, received from Dr A. R. Galloway, has a grey iris, posterior surface of iris is dark; fundus light brown; pecten brown, darkest at crest; nictitating membrane pigmentless. *Microscopical Examination* shows no pigment in nictitating membrane; iris posterior layers deeply pigmented; considerable quantity of brown pigment in stroma principally on anterior surface at pupillary portion; no pigment on anterior surface towards root of iris; ciliary body has a dark epiblastic pigment layer and a quantity of pigment in mesoblastic portion; choroid well pigmented; retinal pigment layer is dark; pecten richly pigmented[1].

This is an example of an abnormal pure white plumaged bird with well pigmented eyes and dark pupil. So far we have not examined microscopically any birds that have pure white plumage and apparently completely albinotic eyes such as the blackbirds on p. 387, although possibly such birds may be found to have complete absence of eye pigment[2].

K. *Incomplete albino Skylark* (*Alauda arvensis*), seen in cage, 1 January, 1910. Although this bird is generally white there are numerous dark feathers distributed amongst the white ones; pupil black, no red reflex could be obtained.

L. *Incomplete albino Skylark* killed in Northumberland and described as a "pure white skylark." Eyes received in formalin 1 October, 1909; iris grey with dark margin at pupil; when the back of the eye is held towards the light a very marked pale, faintly pink, reflex is seen in pupil; no pigment in conjunctiva at corneal margin; fundus is quite dark and so is the pecten; pigment present in ciliary body. *Microscopical Examination*: limbus has no pigment; iris and ciliary body have no pigment in stroma, but their epiblastic layers are well pigmented; retinal epithelium dark brown; no trace of pigment in choroid, yet the pecten contains some pigment.

Normal Skylark with usual plumage of a full grown bird; measures 7″ from tip of bill to tip of tail; has usual long claw on hind toe. Eyes: iris brown with black margin at pupil; pupil is black and no red reflex by transmitted light when eye is held up to window; conjunctiva dark with brown pigment at corneal margin; fundus and pecten very dark, the latter distinctly brown at its base; ciliary body very dark. *Microscopical Examination*: iris darkly pigmented in posterior layers and in stroma; the dark brown stroma pigment is in branched cells; ciliary body darkly pigmented in both mesoblastic and epiblastic portions; much pigment at limbus in subepithelial tissue where it lies in branched cells; no pigment in the anterior epithelium; limbus pigment is continued backwards as a layer external to the bony plate; ligamentum pectinatum and deeper part of sclero-corneal junction well pigmented; dark retinal pigment layer; pecten contains much pigment, most abundant at crest; choroid darkly pigmented, especially noticeable is a broad continuous brown band of pigment next sclerotic.

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[1] A normal wood-pigeon had much more pigment in iris stroma than this white bird, but choroid, pecten and retinal pigment layer had about the same depth of pigmentation as the white bird.

[2] Since this was written a pure white sparrow (p. 397) with albinotic eyes has been examined microscopically and found to have some ocular pigment.

There is a marked difference in the pigmentation of the eye of the albino skylark and that of the normal bird. In the former is entire absence of pigment at the limbus, ligamentum pectinatum, sclero-corneal junction and at parts external to the bony plate. In iris and ciliary body there is no pigment in the stroma of the albino bird and the pigmentless choroid appears very different from the deeply pigmented choroid of the normal bird. Indeed, the pigment of the albino skylark's eye is confined to (i) the epiblastic layers of iris, ciliary body and retinal pigment layer and these appear to be as dark as in the normal bird, and (ii) the pecten which is rather lighter than in the normal bird.

M. *Incomplete albino Lapwing* (*Vanellus vulgaris*). Eye received in formalin, 1 October, 1909. The description given to us is that the bird is very light coloured, nearly white, with no black parts; all the usually black parts are a very pale brown. Bird shot in Stirlingshire. Nictitating membrane has two faint brown pigment bands, the darker and narrower one is at margin of membrane and is separated by a narrow pigmentless zone from the lighter and broader band; no pigment at limbus; iris light brown; ciliary body faintly brown; fundus very light brown; pecten much darker brown than fundus, with a quite dark crest. *Microscopical Examination*: nictitating membrane contains pigment in the epithelial cells at free margin and a pale yellow-brown pigment at intervals in stroma; limbus has yellow-brown pigment beneath the epithelium; pigment extends backwards for a short distance superficially to anterior end of the plate of bone; at deep layers of sclero-corneal junction is a group of cells with brown pigment; iris epiblastic layers darkly pigmented; stroma pigment almost entirely limited to anterior part of iris, where in section it forms a brown band, extending from pupil to base of iris; retinal pigment layer light brown; choroid lightly pigmented and fairly uniformly; pigment is in branched, round and elongated cells, frequently arranged around blood-vessels; pecten contains a moderate quantity of pigment.

Normal Lapwing from Aberdeenshire, received 4 August, 1910; plumage that of a normal full-grown bird. Eyes: nictitating membrane has dark free margin and a lighter brown band at short distance from margin; dark grey band at limbus interrupted and inconspicuous; iris nearly or quite black; fundus and pecten almost black; ciliary body very dark. *Microscopical Examination*: limbus has dark pigment in anterior epithelium and a quantity of pigment in branched cells beneath the epithelium; pigment at deep portions of sclero-corneal junction; iris posterior layers dark and dark stroma pigment especially dense at anterior part.

On comparing the eye of the normal lapwing with that of the albino it is seen that the former is darker in all parts except perhaps the pecten. The light brown iris of the albino bird is in marked contrast to the very dark iris of the normal bird. The red reflex visible in the pupil by transmitted light, when the eye was held towards a window, is more evident than in the normal bird. The fundus of the albino is markedly paler than that of the normal bird and the pigment bands of the nictitating membrane are also paler.

Viewed microscopically the iris in the albino bird differs from the normal bird's iris in containing less and lighter stroma pigment, and lighter (browner) posterior layers. The choroid and stroma of ciliary body are pigmented, but not so darkly as in the normal bird, and retinal pigment layer is not so dark. The pigment in epithelium and subepithelial tissue at limbus of the albino bird is so scanty that it requires careful looking for.

N. *Clear yellow Yellowammer* (*Emberiza citrinella*). Female. During life iris was grey and translucent with red showing through; pupil red reflex; the red seen through iris is least marked near pupil where iris is greyest; with focal light and magnifying glass no ring of pigment was found at pupil margin. Fundus (right eye examined with ophthalmoscope after using a mydriatic) very pale; choroidal vessels clearly seen, in certain positions red reflex was duller and choroidal vessels not seen, thought to be due to presence of the pecten. A normally pigmented pecten is seen ophthalmoscopically, in life, as a dark well-defined body, *e.g.* in the domestic fowl. As the bird was not in good condition it was killed on 11 April, 1911, and both eyes placed in 10 per cent. formalin. *Macroscopic Examination*: eyeballs remarkably translucent; a darker ring corresponds to situation of ciliary body; fundus looks pigmentless; pecten was darker, but when placed in spirit it became quite red (blood-vessels); iris grey; nictitating membrane pigmentless. *Microscopical Examination*: there is no pigment in the eye except at posterior part of iris. Retina, choroid, stroma of iris and ciliary body do not show a trace of pigment; cells of retinal pigment layer apparently well developed; nictitating membrane, sclero-corneal margin and pecten are altogether without pigment; the pigmented posterior layers of iris are not very dark, for the nuclei of the cells are visible.

During life the eye appeared to be completely albinotic. The microscopical examination proved that pigment was present, although limited to the iris. This is the least pigmented bird's eye that we have had an opportunity of examining microscopically.

This bird belonged to Dr A. R. Galloway, who kindly confirmed the notes made of the clinical appearances and gave the eyes for further examination.

The iris of a normal yellowammer is dark brown: see footnote p. 387.

For the eyes of the next seven birds we are also indebted to Dr Galloway.

O (i). *Pure white Canary* (*Fringilla canaria*). Age one week. Left eye (only eye examined) had red colour in pupil when held up to the light. Macroscopically fundus was found pigmented and pecten dark, especially at crest. *Microscopically* examined iris has no stroma pigment; ciliary body no stroma pigment; choroid has no pigment; retinal pigment layer is quite darkly pigmented; pecten contains very dark pigment in form of large granules; epiblastic layer of ciliary body is dark.

O (ii). *Ticked white Canary.* Female, age 4½ weeks (one eye only). Iris grey (cornea *in situ*); pupil and iris have a pink appearance when eyeball is held towards the light; in opened eye ciliary body found dark and fundus pigmented. *Microscopical Examination*: no pigment in stroma of iris and ciliary body; pigment layers (epiblastic) of these two bodies darkly pigmented; no pigment in choroid; no pigment at sclero-corneal junction[1].

P. *Pure white Twite* (*Fringilla flavirostris*). Female, age one year, from Ballymore, Ireland. Both eyes show red reflex in pupil when eyeball is held towards light; nictitating membrane unpigmented; iris dark grey as seen through cornea. Eyes opened equatorially; brown pigment present on posterior surface of iris; fundus generally pale, but is pigmented; pecten has dark crest and grey body. *Microscopical Examination*: no pigment in nictitating membrane and none at sclero-corneal junction; iris epiblastic layers quite darkly pigmented; no stroma pigment in iris or ciliary body; ciliary body has a dark epiblastic layer; choroid contains no pigment; dark brown pigment in retinal pigment layer; pecten fairly heavily pigmented with dark pigment.

This bird and the white canary (*vid.* p. 394) with pure white plumage, having no pigment in mesoblastic structures of the eye, though the epiblastic layers are apparently normally pigmented, are in marked contrast to the pure white wood-pigeon (p. 392), which has mesoblastic pigment as well as epiblastic.

The normal iris is hazel.

The next four birds are hybrids from the same parents. There was a habit to "pink-eyes[2]" and deformed bill.

Q (i). *Canary-Redpoll Hybrid* (No. 1). Age three days, "pink-eyed," no bill deformity, from yellow cinnamon variegated male canary and female redpoll (*Linota rufescens*). Iris epiblastic layers darkly pigmented, no pigment in stroma of iris (sections not complete at pupil region); much pigment in stroma of ciliary body; choroid well pigmented; retinal pigment layer is dark; pecten contains small quantity of pigment in scattered granules; nictitating membrane has fine granular brown pigment limited to the epithelium; no pigment at anterior edge of this membrane.

Q (ii). *Canary-Redpoll Hybrid* (No. 2). Age two days, "pink-eyed," deformed bill and white down. The pigmentation of the eye is similar to that found in next specimen.

Q (iii). *Canary-Redpoll Hybrid* (No. 3). Age one day, "pink-eyed," deformed bill and white down. The eyes of this and the previous bird were similar in appearance and one description serves for both. To the naked eye iris as seen through cornea forms a darker ring over the yellowish lens and is probably pigmented; eye was separated with external ocular muscles, etc., *en masse* and then opened; fundus had a brown colour. *Microscopical Examination*: light brown pigment in retinal pigment layer; no pigment in choroid; extremely little pigment in pecten;

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[1] A yellow canary aged one year, taken for comparison with these two canaries, showed no difference in depth of pigmentation of epiblastic pigment layers, nor was there pigment in any mesoblastic portion of its eye. This yellow canary had a grey iris. In a green-buff canary, however, the stroma of ciliary body and the choroid were well pigmented; iris had no stroma pigment; pecten pigmented.

[2] A term applied to unopened (*i.e.* still covered by lids) eyes only.

iris and ciliary body have no mesoblastic pigment (only part of iris in sections) posterior layers of iris pigmented.

The pecten of the chick is normally richly pigmented by the 17th or 18th day[1], so that in these eyes the marked defect of pigment in it was probably abnormal.

Q (iv). *Canary-Redpoll Hybrid* (No. 4). Female, with deformed bill and "pink-eyed." Iris has brown pigment in posterior layers; no stroma pigment; ciliary body has no stroma pigment, but pigmented epiblastic layer; choroid contains no pigment; retinal pigment layer is quite dark; no pigment at sclero-corneal junction; nictitating membrane is unpigmented.

These four hybrids were all bred from the same parents, as also was a fifth which was "pink-eyed" (unexamined microscopically) and had deformed bill. Five dark-eyed progeny of same parents had no bill deformity.

The three hybrids with deformed bill and "pink-eyed" had no mesoblastic eye pigment. The remaining specimen (No. (i)), with no bill deformity, but "pink-eyed," aged three days, had a well-pigmented choroid and much pigment in stroma of ciliary body.

In *Biometrika*, Vol. VII. Nos. 1 and 2, July and October, 1909, p. 7, Dr Galloway publishes in his paper on Canary Breeding an account of a microscopical examination of eyes from four canaries. Pigment was present in the eye in every case. He has kindly submitted the sections to us. In none of the sections is there mesoblastic pigment, unless pecten pigment is regarded as such. In the yellow variegated canary male, bred from cinnamon father, the epiblastic layers of iris and ciliary body are quite dark; no pigment in iris stroma; no pigment at sclero-corneal junction. The clear buff crest female canary has no mesoblastic pigment in the eye; pecten not in sections; no pigment in nictitating membrane. The canary with cinnamon-marked wings, female, has no stroma pigment in iris and ciliary body; no pigment in choroid; pecten has a quantity of dark pigment throughout, which is darker than the pigment of retinal pigment layer; pigmented layers of iris and ciliary body are darker than the retinal pigment layer; no pigment in nictitating membrane. The clear yellow "pink-eyed" hen canary has no pigment in stroma of iris and ciliary body or in choroid; retinal pigment layer is lighter than posterior layers of iris, which are quite dark; no pecten in sections examined; no pigment at sclero-corneal margin or in nictitating membrane.

The cinnamon greenfinch hen (see the same page of *Biometrika*) has much dark pigment in iris stroma and ciliary body; choroid well pigmented; pigment at sclero-corneal junction. Epiblastic layers of iris and ciliary body deeply pigmented; well-pigmented retinal pigment layer. In the normal wild male greenfinch the pigment has the same distribution as in the cinnamon bird, and from the sections of anterior half of eye we would have difficulty in deciding that the eye of the normal bird was any darker than that of the cinnamon specimen, although the cinnamon's posterior half is lighter than that of the normal bird. Pecten not present in sections examined.

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[1] Foster and Balfour, *Elements of Embryology*, 2nd Ed., p. 148, London, 1883.

R. *White Sparrow* (*Passer domesticus*). Caught ten miles from Lincoln on 7 June, 1911. Its plumage is reported to be pure white. Both eyes, in water, received 9 June, 1911, were transferred to 10 per cent. formalin.

The eyes are translucent at every part. Cornea too opaque to allow a view of iris, which, however, would probably have been visible if it had had the normal dark brown colour. On opening the eye iris found to be grey and translucent[1]; fundus pale; pecten flesh-coloured and, even with a magnifying glass, no sign of pigment; nictitating membrane pigmentless. *Microscopical Examination*: iris has no stroma pigment; the posterior epiblastic layers contain brown pigment, but the nuclei of the cells are quite easily seen; ciliary body has no stroma pigment and only faint pigmentation of the epiblastic pigment layer; no pigment in choroid; retinal pigment layer, though the cells are well formed and hexagonal, contains no pigment, except very far forwards towards ciliary body where they are very faintly pigmented; and at about the same relative position the cells which line the inner surface of sclerotic, in other parts pigmentless, become faintly brown; at posterior part of sclerotic the cartilage is yellowish brown; pecten contains exceedingly pale brown pigment principally at its crest.

S. *Incomplete albino Sparrow* (*Passer domesticus*). Most feathers white, though several dark feathers are amongst them, seen in cage, 1 January, 1910; no red reflex could be obtained in pupil.

Conclusions. The result of macroscopical and microscopical examinations of these few eyes is that there is no constant difference in pigmentation of albinotic and of normal eyes of birds of the same species, and that various degrees and distribution of pigmentation occur from fully pigmented eyes to almost complete albinism. The eye of an albinotic bird may in apparently every respect have normal pigmentation as in the case of our cream-coloured partridge and possibly also in the second partridge, which had, however, a rather lighter iris than the normal specimen when seen macroscopically, although there was no apparent difference in sections, and a less well-pigmented pecten as seen by the microscope. On the other hand pigment may be absent from mesoblastic and epiblastic parts of the eye. As regards the former there may be no pigment in choroid and stroma of iris, although present in stroma of ciliary body, as is demonstrated by the pied rook, in which ciliary stroma pigment was deficient and patchy. In other birds, pigment is completely absent from ciliary body and iris stroma and from choroid, as is the case in the eyes of the three jackdaws and the skylark. In all these birds the epiblastic pigment layers are as dark as in the normal bird. Again, both epiblastic and mesoblastic pigment may be deficient, yet not completely absent as in the lapwing. The epiblastic layers of the eye are in no single case pigmentless at every part, nor are they without pigment where mesoblastic tissue is pigmented. In some eyes without mesoblastic pigment, however, the epiblastic layers, which are pigmented in the normal eye, are in some places deficient in pigment or contain none at all. The extent and degree of the deficiency are evidently variable in different individuals. There is complete absence of pigment from retinal pigment layer and epiblastic layer of ciliary body in the yellow-ammer's eye. The eye of this bird more nearly approaches complete albinism than that of any of the other specimens; it has, however, brown pigment in the epiblastic layers of iris. Then in the white sparrow the epiblastic pigment is practically limited to iris and ciliary body, the hexagonal cells of retina being without pigment. Another variation is presented by the cream-coloured rooks which have the merest trace of brown distinguishable in the retinal pigment layer, besides deficient pigment in epiblastic layers of ciliary body and iris. As none of the specimens have completely pigmentless epiblastic layers, we have not, so far, seen a bird's eye which has been proved to be completely albinotic. The four living blackbirds with apparently completely albinotic eyes—marked red pupils and pale translucent irides—may present this condition, but proof by the microscope is wanting, and when we recollect that apparently equally pigmentless eyes, as those of the yellowammer and cream-coloured rook, may contain pigment, the suggestion must be accepted with reserve until several such eyes of the blackbird are submitted to microscopical examination. The pecten is pigmented in all of the birds' eyes except the yellowammer's. It was remarkable to find this in the eye of semi-albinotic birds where there was complete absence of pigment in mesoblastic tissue of iris, ciliary body and choroid, for the pecten in the chick, according to Foster and Balfour[1], appears on the fifth day and consists of a lamellar process of the mesoblast cells round the eye, passing through the choroid slit near the optic nerve, and as these authors make no mention of any epiblastic cells taking part in its formation the pecten appeared to be the only pigmented mesoblastic part of the eye. But more recently Frank R. Lillie[2] states that the major portion of the embryonic pecten on the seventh day is of ectodermal origin and that the mesoderm forms a relatively inconspicuous part of it. Later on the same day, he says, it becomes increasingly difficult to distinguish ectodermal and mesodermal portions of the pecten, and thereafter it is quite impossible to say which parts of it are of ectodermal and which are of mesodermal origin. From this later account of the development of the pecten, the persistence of pigment in it in some semi-albinotic birds' eyes, where all pigment is quite absent from other mesoblastic parts, may mean that only the epiblastic parts of the pecten are pigmented in these birds and that there is no pigmentation of the mesoblast in any part of the eye. Indeed, we are told that the morphology of the pigment excludes the like nature of that in the pecten and in the choroid[3]. Most of the pecten pigment in our birds' eyes has the form of spheres, which are larger than the round choroidal pigment granules and of a very different shape from the needle-like forms of the retinal pigment. As regards the relationship of the amount and distribution of eye pigment to the colour of plumage, it is obvious from these specimens that a bird wholly with pure white feathers may have either a black pupil with correspondingly well-pigmented epiblastic and mesoblastic eye tissues, as in the wood-pigeon, or a red pupil with a nearly pigmentless eye, as in the sparrow. Of the pure white specimens the pigeon is the only one with mesoblastic pigment, the others have epiblastic pigment, though scanty in the sparrow, but no mesoblastic pigment. By far the larger proportion of white birds, say Macpherson, Stuart-Wortley and Saintsbury in their account of the Partridge[1], are examples of leucotism, a term used to explain the conjunction of pure white plumage and irides of normal colour. Birds with generally normal plumage, but with some abnormal white feathers, to judge from the pied rook and blackbird, have both epiblastic and mesoblastic pigment, though the former bird had mesoblastic tissues pigmented in the ciliary body only. The birds with uniform pale plumage, "silver grey" or "slate coloured," have all got well-pigmented epiblastic layers in iris, ciliary body and retina, but some have complete absence of mesoblastic pigment—three jackdaws, while others have well-pigmented mesoblastic tissues—blackcock and grey-hen. The material at hand gives no indication as to whether one pale-plumaged bird can have mesoblastic pigment in the eye, whilst another of the same species is without it or *vice versa*. Are pale grey black-game found without mesoblastic eye pigment and jackdaws of the same colour with it? Other uniformly pale-coloured birds, but cream-coloured, have in some cases well-pigmented eyes in all parts—partridge, in other cases—two rooks, no stroma pigment and very deficient epiblastic pigment.

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[1] The iris of a normal sparrow is dark brown: see footnote p. 387.

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[1] *The Elements of Embryology*, 2nd Ed., p. 147, London, 1883.

[2] *The Development of the Chick*, p. 282, New York, 1908.

[3] *Handbuch der vergleichenden mikroskopischen Anatomie der Haustiere*, Bd. I., Berlin, 1906, p. 494.

SECTION IX. *General Bearing of the Results of this Chapter on the Albinotic Eye in Man.*

In the previous chapter we have seen how complex is the nature of the albinotic hair in man; that the pigmentation associated with the hair of albinos is not capable of being described by the absence of a single factor, that pigment may occur in more than one form, and that probably theoretically complete albinism of the hair must be defined as hair in which granular pigmentation is absent. It is, however, very doubtful whether any majority of "clinically" certified albinos attain this theoretical condition, and it is equally certain that individuals exist who satisfy this condition, and who have not been suspected "clinically" of albinism. The test itself can only be applied after microscopical examination of a very large sample of the hair, for we have seen that some hairs may contain granules although others are absolutely without them. While it is relatively easy to obtain albinotic hair samples and to examine them microscopically, it is by no means easy to obtain human albino eyes, and the work of examining them microscopically is of a much more serious character. The few albinotic human eyes with the structure of which we are acquainted seem to indicate that a "clinically" albinotic human eye need not satisfy the condition of theoretical albinism, *i.e.* absolute absence of pigmentation, when examined microscopically. As the problem of the human eye could not be investigated fully for lack of material, the present chapter on the albinotic eye in the lower animals was undertaken. The researches of the present chapter have shown how complex is the problem of the albinotic eye. Almost any grade of albinism of the eye may occur, and this may be associated with almost any grade of albinism of the coat, and the extent of both albinism of the eye and of the skin can only be determined after prolonged microscopical investigation, which in the case of the human albino must generally be *post-mortem*. Under such circumstances it is difficult, if not irrational, to speak of albinism as a simple unit character. It is a feature of the greatest complexity, and its graduations are as significant physiologically as they are important from the standpoint of heredity. Luckily, since the chapter on the Human Eye was printed off, K. Pearson has received from Dr G. A. Turner[1] the eye of a negro albino, together with specimens of scrotum and scalp with wool. The case was that of a M'hambane boy, about 22 years of age; the cadaver occurred in a medico-legal investigation, and a complete examination was not possible. The boy was probably a "clinically" complete albino. Microscopically the wool showed extremely pale-yellow diffused pigment, no granules, and a few vacuoles, *i.e.* there was complete albinism of the hair. The scalp and scrotum have been handed to Dr W. Bulloch who reports an entire absence of pigment: see Appendix A.

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[1] *The Partridge—Fur and Feather Series*, London, 1893, by Rev. H. A. Macpherson, A. J. Stuart-Wortley and George Saintsbury.

The eye was sent to Mr George Coats, who has kindly prepared the accompanying report:

Report on the Eye of an Albinotic Negro. By Mr George Coats. The globe was slightly collapsed when received. Apart from some leucocytal infiltration in the intervaginal space of the nerve, and some evidence of some old superficial injuries of the cornea, there are no pathological changes. Owing to commencing *post-mortem* change, no statement as to the structure of the rods and cones is possible.

Pigment epithelium. In the iris the epithelium is pigmented throughout. The tint is a medium brown, considerably lighter than in the normal blue European eye. Of the derivatives of the epithelium, clump cells (see p. 356) are few in number and collected mostly in the neighbourhood of the sphincter; their pigment is coarser and darker than that of the posterior epithelial cells. Grunert's spur (see p. 356) is the only one which is well developed; v. Michel's is indicated. The dilatator is slightly pigmented, the sphincter unpigmented. Apart from some irregularity on the ciliary processes—which is not uncommon in the normal eye—the epithelial pigmentation of the ciliary body is uniform and fairly deep; it is certainly as deep as in many European eyes; no clump cells are present. Behind the ora serrata the pigmentation rapidly decreases, and is very light in the whole of the posterior part of the globe. Except in the immediate vicinity of the nerve entrance, however, none of the cells are without lightly-coloured granules. The depth of pigmentation in the macula is about the same as elsewhere.

Stroma pigment. Stroma pigment is completely absent in the ciliary body, choroid, sclero-corneal margin and along the perforating nerves and vessels. The epithelium of the limbus corneae is also unpigmented. In the ligamentum pectinatum a few pale chromatophores occur. In the iris chromatophores are abundant. They show the usual aggregation in the anterior layers of the stroma, and are also more numerous towards the sphincter margin than near the root. The individual cells seem to be well filled with pigment granules, which, however, are abnormally light in tint.

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[1] Dispatched from Johannesburg, April 30, 1911.

The case, therefore, is one of incomplete albinism, the retinal pigment being represented in all, the stroma pigment in some, of its normal situations. From a study of the chromatophores of the iris, and of the epithelium in the posterior part of the globe, the impression conveyed is that the pigment-bearing apparatus, even to the intracellular granules, has been developed, but has not received its full charge of colouring matter.

In a covering letter Mr Coats writes with reference to the last words of his *Report*: "If I remember rightly the same thing was shown in one of the Pekinese dogs[1]; also a case of incomplete albinism. Is there any evidence as to how much of the pigment-bearing apparatus is developed in complete albinism?"

The resemblances in hair, skin, and eye of the Negro albino and of the Pekinese albino spaniel are very considerable. In hair and skin both are complete albinos (see Appendices A and B to this chapter); both are incomplete albinos of the eye. Manz's case[2] may also be taken into consideration. This chapter shows at least real ground for suspending judgment as to the prevalence of complete albinism of the eye in "clinically" complete human albinos, and in man the theoretically complete albino eye may be after all as rare as it appears to be among birds and among some of the lower mammals.

Descriptions of Colour Plates ϵ, ζ, and ρ, illustrating this Chapter.

Plate ϵ. Microscopical drawings to show the condition of the Iris and Choroid in respect to pigmentation in a Partially Albinotic Dog and Horse, and in Completely and Incompletely Albinotic Mice. Drawings from the corresponding parts in normally pigmented eyes for comparison.

Figures 1 to 5. From different parts of the same eye of a "wall-eyed" dog. Mr Coats's Case III (p. 360).

1. From the white part of the iris; pupillary edge of iris on the right, ciliary process on the left. The posterior (retinal or epiblastic) pigment layer (in reality a double layer) fully pigmented. The few scattered dots of pigment in the substance of the iris immediately in front of the posterior layer are "clump-cells" believed to be derived from the retinal layer; with the exception of these cells the iris stroma is absolutely free from pigment.

2. Choroid with its retinal epithelium from the equator of the eyeball. Both are pigmented. The cells of the retinal epithelium (*e*) are not very highly pigmented and are not quite in profile, but slightly tilted (cf. Fig. 5).

3. From the brown part of the iris. Besides the retinal pigment layer and the clump-cells, the stroma of the iris shows a quantity of pigment in the form of short lines and branched figures, the stroma or mesoblastic pigment. Pupillary edge to left, ciliary process to right.

4. Choroid from another part. The choroid itself is normally pigmented, but the retinal epithelium (*e*) is absolutely devoid of pigment; the cilia-like appearance is due to fragments of the outer limbs of the rod and cone layer adhering to the epithelium.

5. Choroid from another part. No trace of pigment in the choroid itself, but the retinal epithelium (*e*) strongly pigmented, the pigment being collected chiefly towards the inner or retinal part of the cells (the lower free border of the drawing). Figures 1 and 3 × 30, Figures 2, 4 and 5 × 200.

Figures 7 and 8. Iris (pupillary part only) (Fig. 7) and Choroid (Fig. 8) from a normal brown-eyed horse. C. H. Usher's Case I (p. 367). Both epiblastic and mesoblastic pigment is fully developed in each, even more than in Figs. 3 and 2 from the dog. The thin (left hand) end of the iris (Fig. 7) is composed almost entirely of unstriped muscular fibres constituting the sphincter muscle; the epiblastic pigment is much thicker at this part. The anterior surface (upper in the figure) is covered by a single layer of flattened cells easily recognized by their brown colour; in parts they have become artificially separated. In this section no clump-cells are noticeable. Figure 7 × 30, Figure 8 × 200.

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[1] See p. 362 *supra*.

[2] See pp. 3, 271–2 *supra*.

Figures 6 and 10. Iris (pupillary part only) and Choroid from a white-eyed ("wall-eyed") horse. C. H. Usher's Case II (p. 369 *supra*). Epiblastic pigment well developed in both, but no trace of mesoblastic pigment is present in either. The iris is much thinner than, and its contour different from, what is seen in Fig. 7; the difference is explained chiefly, if not entirely, by the different state of contraction of the sphincter and dilatator muscles respectively in the two specimens. The large empty spaces in Fig. 10 are veins, the two small vessels, arteries, full of small cells (blood corpuscles). In comparison with Fig. 8 the veins are enormously distended; but such differences in the blood-contents of the choroid between one specimen and another are very common in post-mortem eyes, and have no bearing on pigmentation. Figure 6 × 30, Figure 10 × 200.

Figures 9 and 11. Iris and Choroid of wild house mouse. Mr Coats's Case I (p. 363 *supra*). In Fig. 9 the distinction between epiblastic layer (*e*) and mesoblastic layer or stroma (*m*) is difficult to make out owing to the thinness of the iris and the large quantity of darkly coloured and densely aggregated pigment; the distinction is best seen at the pupillary edge (left in the figure) where the sphincter muscle is plainly shown. The pigment in this section is sensibly black except when the granules are seen in looser grouping; they may then be called the deepest possible shade of brown. × 200.

In Fig. 11, from the same eye, *s* represents the sclerotic, included in the section owing to the thinness of the tunics. × 200.

Figures 12 and 13. Iris (13) and Choroid (12) of a completely albinotic mouse. Mr Coats's specimen Case VI (p. 365 *supra*). No trace of pigment is present in any part of either specimen. In Fig. 13 the stroma (above in the figure) is separated by an apparently structureless layer, representing the sphincter and dilatator muscles, from the retinal (epiblastic) stratum (below in the figure). The two layers of cells of which the latter stratum is composed are fairly well shown. The muscular layer is perhaps made a little too thick in the drawing. The projection on the surface of the stroma layer is a blood-vessel. In Fig. 12 the mesoblastic layer of the choroid (*m*) can be distinguished from the retinal epithelium (*e*) and sclerotic (*s*) only by the different size and shape of its nuclei. × 200.

Figures 14 and 15. Part of the Iris (14) and Choroid (15) from a mouse with a light-red sandy coat and almost completely albinotic eyes. Mr Coats's Mouse, Case IV (p. 364 *supra*). In Fig. 14 (Iris) the stroma (above in the figure), contains some light yellowish brown pigment in a finely granular form. The retinal layer (below in the figure), contains no trace of pigment. Pigment of the same colour is present in the choroid (Fig. 15 *m*), but only in small areas here and there, the intervening portions being free or showing only a few scattered granules in some of the cells. The retinal epithelium (*e*) is colourless everywhere. × 300.

Plate ζ. Illustrating eyes of Normal and Wall-eyed Horse, and the difference in pigmentation between the eyes of individual Hares (*L. variabilis*).

Normal Horse.—1. Choroid posterior half, retina removed, from dark brown horse.

Exceedingly dark fundus, darkest below tapetum; tapetum with well-defined lower margin, ill-defined elsewhere, purple colour, most marked below; optic disc just below tapetum.

2. Normal Iris,—from same eye as 1. Front view, cornea removed.

Very dark brown with concentric folds, darker zone next pupil; dark corpus nigrum projecting into upper part of pupil; lens opaque.

Wall-eyed Horse.—3 and 4. Antero-posterior section, crystalline lens and retina removed.

Upper part of each half adjacent in drawing.

Fundus pale brown, darker below; part below tapetum of nearly uniform colour, and darker than rest of fundus. Tapetum, well-defined lower edge, ill-defined elsewhere, is exceedingly pale, at anterior part green iridescent area; in upper part of fundus are large areas which in reality were a good deal whiter than the drawing would suggest. This patchy appearance is not present in the normal eye; optic disc just below tapetum (Fig. 3); posterior surface of iris and ciliary body very dark; corpus nigrum at upper part of pupil margin, projecting into pupil; stroma of iris white, continued into the whitish stroma of ciliary body.

5. Iris—front view, cornea removed.

From same eye as 3—4.

White with concentric folds; slate-blue zone next pupil, with dark pupil edge, and dark corpus nigrum projecting into pupil at upper part. Lens opaque.

Mountain Hare.—*L. variabilis.* 6. Iris of January Hare.

Front view, cornea removed.

Pale brown, showing darker diamond-shaped surface marking; pupil grey due to opaque lens; dark lines in pale area beyond iris are pigment at limbus of cornea.

7. Iris of August Hare.

Front view, cornea removed.

Very dark brown; pupil black, from absence of lens, which may explain the marked, artificial, radial folds; dark lines in pale area beyond iris are pigment at limbus of cornea.

Plate ρ. Illustrating pigmentation of irides of Human and Canine Albinos with completely albinotic Skin and Hair.

Figure 1. Microscopical section of Choroid of albinotic Negro. Case: see p. 399. × 200.

Scl. Sclera, *ch.* Choroid, *e.* Retinal pigmented epithelium, forming a single layer which is continuous with the outer or pigmented layer in the ciliary region (Figs. 2 and 4 *e.*). The cells of this layer contain yellowish brown pigment in considerable quantity, but less in amount and much lighter in colour than in the ciliary region, or in the normal European eye. No pigment at all in the choroid.

(In a normal negro eye both *ch.* and *e.* would be very heavily pigmented.)

Figure 2. Ciliary body of the same negro eye. × 50.

cm. Ciliary muscle, *e.* two layers of retinal epithelium, *Scl.* Sclera, *i.* root of iris. The depth of pigmentation in the outer layer of the retinal epithelium (the only layer normally pigmented in this situation) is greater than in any other part of this globe, or in the corresponding part of Fig. 4; and although much lighter than in the normal Negro, it approximates to that of the average European eye. There is no pigment in the stroma of the ciliary body.

(In the normal Negro the bundles of the ciliary muscle (*cm.*) are mapped out by deeply pigmented strands.)

Figure 3. Iris of same negro eye. × 100.

e. Retinal epithelium, containing pigment of a medium brown tint, decidedly lighter than in the normal European eye. Chromatophores are fairly abundant, especially in the anterior layers of the stroma. Blood vessels cut longitudinally and transversely.

Figure 4. Ciliary region and periphery of iris of male albino Pekinese puppy, XI. 29 in our Pekinese Pedigree; born 31 January, 1910, died in two or three hours. Fixed in Zenker's fluid. × 75.

scl. Sclera, *cm.* Ciliary muscle, *e.* Outer or anterior layer of retinal epithelium, *pe.* Inner or posterior layer of retinal epithelium on iris. *c.p.* a ciliary process, *c.* Cornea, *i.* Iris.

Posterior or inner surface of the iris, ciliary processes and ciliary muscle lined by a double layer of epithelium (*e.*, *pe.*), of which the cells forming the outer layer contain a considerable quantity of pigment of yellowish brown colour. On the iris a few granules were also present in the inner or posterior layer. Under higher magnification a certain number of pigmented cells, probably clump-cells, can be seen in the stroma of the ciliary body. In the iris there is no stroma pigment. Two blood vessels cut across in the iris are packed with red blood corpuscles.

(It may be explained that in a corresponding section of a dark coated dog the epithelium (*e.*) is so highly pigmented as to appear black.)

Figure 5. Ciliary region and part of iris of female albino Tong I, VII. 17 in our Pekinese Pedigree; aged 6½ years. × 25.

Lettering as in Fig. 4.

In the epithelium of the iris and ciliary body the pigmentation is fairly deep. The pigmentation of the stroma is not visible with this power; it consists of isolated cells, more abundant in the iris than in the ciliary body.

(In the dark-coated dog the iris and ciliary muscle and processes are crowded with very dark pigmented cells, and a considerable number of similar cells are present in the sclera.)

APPENDIX A. REPORT ON THE SKIN OF AN ALBINO NEGRO.

By W. BULLOCH, M.D.

At the request of Professor Karl Pearson I have examined two pieces of skin which were stated to have been obtained from an albino negro. One of the pieces was from the pubis and was covered with curly hair presenting a definite yellowish colour. On section the skin appeared to be totally devoid of pigment macroscopically. The other piece was said to be part of the scalp. The method of fixation which had been employed was evidently different, the pubic portion being colourless, whereas the scalp portion was a dark greenish colour, and its consistence was so brittle that it was found to be impossible to make microscopic sections which could be satisfactorily examined. The pubic portion, on the contrary, was easily cut both as frozen and as paraffin sections. A large number of such sections were cut; some being left unstained, others being stained faintly by carmine or neutral red. The sections were first examined under $\frac{1}{6}$-inch objective, and were then carefully studied under $\frac{1}{12}$-inch. The layers of the skin are normally formed, with the exception of the fact that no visible pigment can be found in the deep cells of the rete Malpighii. This statement is made after a very careful search of many sections under $\frac{1}{12}$-inch objective. All the cells appear to be unpigmented; in particular there is no evidence of pigment in the neighbourhood of the nuclei. The sweat glands appear normal. A large number of hair follicles have been cut across at various angles in the sections, and it is at once apparent that the substance of the hair itself is the seat of a diffuse yellowish or brownish pigmentation. No definite granules of pigment are visible. No granules could be found in the various cells surrounding the hair follicles. There appears indeed to be an absence of pigmentation—diffuse or circumscribed—in the cells of the skin and hair follicles, the only evidence of colouring matter being the diffuse pigmentation of the hair itself. In the cutis numerous branched cells are visible having the habitus of connective tissue corpuscles, but in none of them could pigment diffuse or otherwise be determined with certainty.

[The wool of this negro had the definite yellow tinge characteristic of so many albinos of dark-skinned races: see Chapter VIII and Plate κ. Clinically he would no doubt be reported as a complete albino negro; unfortunately the internal organs were not available. See p. 400 for an account of his eyes. K. P.]

APPENDIX B. HISTOLOGICAL EXAMINATION OF ORGANS AND TISSUES OF THE ALBINO PEKINESE OR DONDO BITCH "TONG I."

By ALEX. LOW, M.B.

At the request of Professor Karl Pearson the various organs and tissues of his albino bitch "Tong I" were sent to me by Dr Bulloch for histological examination. Pieces of all organs and tissues were received except the eyeballs, which were sent to Mr Coats, and the uterus which was septic and retained by Dr Bulloch.

All tissues had been fixed in formalin (4 °/。) and were washed, dehydrated in alcohol and embedded in celloidin. Both petrous bones containing the middle and internal ears were decalcified and also finally embedded in celloidin. Sections of each organ and tissue were examined microscopically, some unstained, others stained by paracarmine. The histological preservation of the tissues was excellent.

As regards brain no trace of pigment was detected after examining many sections through its different parts. Sections of cerebrum, olfactory lobe, pituitary body, mid-brain, cerebellum, pons and medulla and preparations of dura mater were examined.

The internal ear contained no pigment in the walls of the perilymph chambers —the region of the stria vascularis was especially examined, since pigment, if present, is usually found there; in the non-albino dog, however, pigment may be entirely absent from internal ear. The olfactory mucous membrane was unpigmented.

The appearances presented by sections of skin from abdominal wall, skin of face and horizontal and vertical sections through upper and lower lips were normal, but showed no trace of pigment. Sections of hairs, including the large sinus hairs, cut in different directions, were devoid of pigment either granular or diffuse.

Sections of thyroid and parathyroid, thymus, lymphatic gland, mucous membrane of mouth, tongue, trachea, oesophagus, stomach, intestine, spleen and kidney were free of pigment. The lungs showed very distinctly carbon particles especially grouped in the tissues round the larger blood vessels. Sections of the liver showed areas in which were to be seen distinct small dark brown pigment granules; these granules mostly lay in the capillary blood vessels either free among the blood cells or in some cases in white blood cells.

The suprarenal glands showed no trace of pigmentation either diffuse or granular, the mesentery and solar plexus region were also pigment free.

In conclusion, as the result of a careful examination by ordinary histological methods of those organs and tissues, no pigmentation was found except in the liver, and here it was evidently a pathological formation.

[Since the printing of this appendix Dr Low has examined with entirely confirmatory results the internal organs of two more Dondo bitches. The reports of these examinations will be printed in the Chapter on Albino Dogs. K. P.]

APPENDIX C. ADDITIONAL NOTES ON ALBINOTIC BIRDS' EYES, RECEIVED SINCE THE PRINTING OF THIS CHAPTER.

By C. H. USHER.

T. *Wood Pigeon* (*Columba palumbus*). From Peeblesshire, 28th Dec. 1910; plumage "pure white." Eyes: macroscopically iris is pale as seen through cornea, darker at pupil; on opening eyeball, ciliary body, fundus and pecten are seen to be dark, especially the ciliary body; nictitating membrane is pigmentless. Microscopical examination: nictitating membrane pigmentless; no pigment at limbus corneae; iris has no stroma pigment, posterior layers darkly pigmented; stroma of ciliary body lightly pigmented, epiblastic layer dark; choroid contains very little pigment; pecten dark. On comparing with a normal wood pigeon's eye, the scanty pigmentation of choroid in the white bird is in marked contrast to the well pigmented choroid of the normal bird. The eye of this bird also differs from that of the normal bird in the absence of pigment at limbus and in absence of pigment from iris stroma. The epiblastic pigment layers of iris, ciliary body and retina are as dark as in the normal bird and so is the pecten.

U. *Wood Pigeon* (*Columba palumbus*). From Fifeshire, 4th Nov. 1910; plumage "very pale," and said to be yellowish brown. Eyes received in 10 per cent. formalin are much shrunken and flattened, probably a long interval elapsed between time of death and immersion in the formalin. From microscopical examination it can be stated that choroid and retinal pigment layer are darkly pigmented, also that epiblastic layers of iris and ciliary body are dark, but it is more uncertain as regards the iris stroma and ciliary body stroma, as these parts are torn and thick in the sections; it cannot be said that they are pigmented.

V. *Grouse* (*Lagopus scoticus*). From Haddingtonshire, September 1911; plumage nearly uniform pale yellowish brown. The eyes macroscopically are normally pigmented. Microscopical examination: iris darkly pigmented in stroma and posterior layers; ciliary body mesoblastic and epiblastic parts darkly pigmented; no pigment at limbus, either in epithelium or in subepithelial tissue; choroid and retinal pigment layer deeply pigmented; pecten contains much dark pigment.

W. *Mallard* (*Anas boscas*). From Berwickshire, 5th Nov. 1910; plumage "white"; "eyes dark." Eyes received in 10 per cent. formalin much shrunken. Microscopical examination: no pigment at limbus corneae, nor in iris stroma, nor in stroma of ciliary body; no pigment in choroid; epiblastic pigment layers of retina, ciliary body and iris are dark; pecten is very dark. In this duck there is accordingly entire absence of pigment from the mesoblastic portions of the eye, unless pecten is an exception, and normal pigmentation of the epiblastic portions of iris, ciliary body and retinal pigment layer.

An eye of a normally plumaged mallard had pigment in epithelium and subepithelial tissue at limbus; much stroma pigment in iris and ciliary body; well pigmented choroid and pecten; epiblastic pigment layers of iris, ciliary body and retina are apparently of same depth of pigmentation as those of the white bird.

X. *White Robin* (*Erithacus rubecula*). Killed in Roxburghshire, 26th August 1911; plumage is described as "white all over with the exception of the tail, which shows the faintest semblance of a pale grey bar"; another account says that the robin was "quite white but for a very faint cinnamon bar on tail"; beak and legs have usual colour of an adult bird, "the eyes are black." Both eyes, received on 30th August, dry and flattened. Microscopical examination: notwithstanding the condition in which the eyes arrived the sections show quite clearly that the eye is well pigmented; iris[1] posterior layers and stroma are darkly pigmented; much pigment at limbus in subepithelial tissue; ciliary body deeply pigmented in epiblastic and mesoblastic portions; choroid well pigmented; retinal pigment layer quite dark; pecten very dark, especially the crest, which is black.

Y. *Linnet* (*Fringilla linota*). Female with silver grey plumage. Eyes, received from Dr Galloway, are macroscopically dark externally; fundus, pecten and ciliary body are dark. Microscopical examination: pigment present at limbus; iris[2] has well pigmented stroma and dark posterior layers; ciliary body stroma pigmented, dark epiblastic layer; choroid has very dark pigment and is richly pigmented; retinal pigment layer contains well marked brown pigment; pecten is most densely pigmented at crest.

Z. *Hedge Sparrow* (*Accentor modularis*). Female, with cinnamon plumage. Eyes, received from Dr Galloway, 17th October 1911; eyeball is translucent; marked red reflex in pupil; macroscopically iris[3] is rather pale brown; one eye opened for further examination, fundus is very pale brown; pecten has pigment visible on its crest, seen with difficulty without a magnifying glass; ciliary body brown like iris; nictitating membrane has two pale pigment bands, the less conspicuous one is at free margin of the membrane. Microscopical examination: no pigment at limbus; iris has light brown stroma pigment and darkly pigmented posterior layers; ciliary body has some stroma pigment and a pigmented epiblastic layer; cells of retinal pigment layer contain no pigment except those near ora serrata and these contain only a small quantity; choroid is lightly pigmented; pecten pigmentless except at crest, where there is a considerable quantity of dark pigment.

This is an example of a bird's eye with pigment present in the choroid (mesoblastic), whilst pigment is absent from the retinal pigment layer (epiblastic).

A number of our birds' eyes were obtained through the kindness of taxidermists, especially Messrs Small and Son, Edinburgh, and Messrs W. A. Macleay and Son, Inverness.

It will be seen that the hedge sparrow is the most interesting of the above birds, for it is a case with no pigment in the retina, whilst pigment was present in the choroid. The "completely albinotic" bird's eye seems as far removed as ever from our field of investigation.

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[1] Iris of the normal robin is dark brown.

[2] The normal linnet has a deep brown iris.

[3] Iris of the normal hedge sparrow is dark blackish brown with a tint of red (Morris).

CHAPTER X.

ON THE SEASONAL VARIATION OF WINTER WHITE ANIMALS.

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SECTION I. *Introductory.*

THE following investigations on the eyes and coats of winter white animals were undertaken in view of the possibility that the changes associated with temporary leucosis might throw light on the nature of leucoderma and possibly of congenital albinism. It appeared of interest to investigate not only the nature and reason of the coat changes, but also the possibility which has been sometimes asserted for a corresponding change in eye pigmentation. The whole of the researches in this chapter are due to C. H. Usher. The appendix on the nature of the pigmentation in the hairs of the coats has been prepared by Miss E. Y. Thomson. While little has been ascertained that bears obviously and directly on congenital albinism, the observations recorded are of interest in themselves and may ultimately be of service to our main inquiry when the knowledge of leucosis in all its phases is wider than at present.

SECTION II. *Examination of the Eyes of* Lepus variabilis *at different Seasons of the Year.*

In a note[1] published in 1838 Carron du Villards, then professor of ophthalmology in Paris, makes the suggestion that the pigmentation of the eye of the variable hare changes with the seasonal change of the coat colour. His words are as follows:

> "Dans les Hautes-Alpes, je tuai un lièvere blanc (*Lepus variabilis*) au moment où il quittait son pelage albinos pour prendre son habit d'été. J'observai avec surprise que les yeux n'etaient de la même couleur dans toutes leurs parties, et l'on voyait distinctement la coloration rose disparaître pour faire place à la brune, qui est la couleur habituelle des yeux de cet animal pendant l'été."

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[1] See Bibl. No. 220, p. 276.

Now this statement is somewhat remarkable. First, because Carron du Villards was an ophthalmologist who knew what he was talking about when he spoke of the rose coloration of albino eyes. He had written on the albino eye in man and he was one of the few people who had dissected a human albino eye. Secondly, because he seems to express surprise that he had killed a hare with eyes in the *transitional* state, rather than with the existence of any change at all. He even went further and suggested that this seasonal change in the hare would provide a method of testing how the black pigment which replaces the albinism of the eye is secreted.

Several sportsmen appealed to on this point ridiculed the idea that any change in the pigmentation of the eye took place, but none were able to say that they had *closely* examined the eye of the variable hare at different seasons[1]. It seemed just possible that a change detected by an ophthalmologist might not be apparent to the men, whose attention had not been especially drawn to the exact nature of the point at issue, and who failed on enquiry to remember any definite examination of the eye on a definite occasion. Accordingly it seemed just worth while making a careful study of whether there was any change, however slight, between the winter and summer hare. This might be done by two different processes: (1) by obtaining specimens of the variable hare under different seasonal conditions, and (2) by watching individual hares in captivity from season to season. In this way it might be possible to verify or refute Carron du Villards' observation[2]. It was fairly easy to carry out the first of these methods and specimens were procured. There was some difficulty in procuring living hares, but owing to the courtesy of Dr V. Magnus a male and a female *L. variabilis* were captured in a Norwegian island and were safely transported to Aberdeen, where they have not only thrived but successfully bred, numbering now seven. The whole investigation has been in the hands of C. H. Usher.

(1) Twenty-four hares were examined. We owe them principally to the kindness of Dr Howie of Strathdon, who sent them from upper Donside, Aberdeenshire; two were sent by Professor Norman Collie from Skye, and one hare came from Ross-shire.

The value of the investigation at once appears if we consider Hare No. 23, killed August 24, 1908, and compare it with Hare No. 5, killed January 21, 1909, these two hares having respectively the dark and white, or summer and winter coats. On Plate ζ, Fig. 6, is given a reproduction of the eye of the January hare and Fig. 7 one of the August hare, the eyes are represented after the removal of the cornea. The conclusion to be drawn from these two hares, among the earliest examined, might well be that the iris had less pigment in the winter than in the summer. But an examination of a much larger number of hares demonstrated that there is no constant shade of brown in the iris of the mountain hare, but that all shades from a light creamy yellow to a rich dark brown occur within the species, and that this individual variability is independent of the season or coat colour. Hence observation made by our first method unless the number of hares be very large may easily be inconclusive. The following is the list of hares dealt with.

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[1] On the other hand a number of gamekeepers who have spent their lives amongst the hills and have seen large numbers of mountain hares at all seasons of the year were asked as to this point. None of them could say that the eye altered in colour. The usual reply given was that they had paid no particular attention to the matter so could not say, although they were aware that some people believed that there was a change in the eye colour as well as in the coat colour.

[2] It would, perhaps, be best to say, verify or refute its generality. We can hardly suppose that there was not something anomalous in the hare he himself examined; possibly it was an incomplete albino, or the eyes may have been injured; there is no statement that he removed and dissected them.

Index No.	Date	Coat	Locality	Index No.	Date	Coat	Locality
3	K. 26/10/09	Change†	Aberdeenshire	4	R. 25/5/09	Dark	Aberdeenshire
14	K. 26/10/09	„ †	„	11	R. 25/5/09	„	„
20	R. 26/11/09	White	„	7	R. 19/6/09	„	„
22	R. 26/11/09	„	„	9	R. 19/6/09	„	„
8*	R. 22/12/08	„	„	17	K. 20/7/09	„	„
5	K. 21/1/09	„	„ §	21	K. 28/7/09	„	„
1	K. 24/2/09	„	„	24	K. 28/7/09	„	„
16	K. 24/2/09	„	„	23*	R. 25/8/08	„	„
2	K. 23/3/09	„	„	13	K. 30/8/09	„	„
19	K. 23/3/09	„	„	12	K. 30/8/09	„	„
10	K. 19/3/09	„	Skye	6	R. 29/9/09	„	„
18*	K. 24/4/08	Change‡	Aberdeenshire	15	R. 29/9/09	„	„

K. = killed, R. = received. * 8, 18 and 23 belong to the year 1908. † "More summer than winter coat." ‡ 18 is "white but changing." § 30 miles lower down Donside.

The irides were now arranged in series and judged in the absence of the coats by C. H. Usher (i), Dr William C. Souter (ii), and an artist (iii). Their ranking in term of C. H. Usher's, which has been used for index numbering, is as follows, the lower rank meaning the paler iris:

(i)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
(ii)	1	7	8	3	2	5	10	6	4	9	13	11	16	15	20	14	18	17	12	19	21	24	22	23
(iii)	1	3	9	2	4	6	10	7	8	5	11	17	15	16	19	20	18	13	12	14	21	22	23	24

This must be interpreted as follows: (i) made No. 4 iris, *i.e.* that of hare of May 25, 1909, the lightest but three of the whole series, (ii) made it the lightest but eight and (iii) made it the lightest but four. The agreement on the whole is good. Each of the three select the same irides as the lightest ten and the same four as the darkest four. To test the effect, if any, on the irides of the season we have taken the mean ranking of all three observers for (*a*) the hares with white or winter coating, (*b*) for changing coating and (*c*) for dark or summer coating. We find:

	Average Rank
Winter coating	10·5
Changing coating	12·6
Summer coating	13·9

Although the number of hares is relatively small the sequence is very orderly and so far as it goes suggests that the irides of the summer hares are slightly darker than those of the winter hares. To test the point further we note that the change of coat appears to take place in April and October, and we can take two months one on either side of this to cover variation. In other words we may take December, January, February for the full winter months, and June, July, and August for the full summer months. The hares shot in the first period were Nos. 8, 5, 1, 16 and in the second period Nos. 7, 9, 17, 21, 24, 23, 13, 12. In both these groups the lightest and darkest irides respectively fall in the middle of the period. Expressing this as before by the average rank which the three observers give to the group we have:

Mid-winter Rank	7·0
Mid-summer Rank	16·1

Or, we see that the former difference (10·5 to 13·9) has been very largely increased by confining our attention to the middle of the summer and winter periods. Arranged in this way we have:

Mid-winter (Dec., Jan., Feb.) Rank	7·0
Change to summer (March, April, May) Rank	10·1
Mid-summer (June, July, Aug.) Rank	16·1
Change to winter (Sept., Oct., Nov.) Rank	14·3

Thus by this method of comparison there would appear to be some slight evidence of a change in the intensity of the pigment in the iris.

It must however be added that other methods of comparison of iris colour of winter and summer coated hares were made with the result in favour of the view that there is no sensible seasonal variation in the iris colour. The same eyes were used and in addition eyes from three Ross-shire hares and eyes of three hares from the far north of Scotland. A group of unselected eyes from the hares with summer coats was placed beside a group of eight unselected eyes from the hares with winter coats. Taken as a whole the irides of the summer group were darker than those of the winter group, but when a second group of eight unselected eyes from hares with summer coats was compared with the same winter group it was apparent that the irides of the winter group were then darker than those of the summer group. It may be that a more true impression of the depth of pigmentation is obtained by comparing groups than by comparing two individual eyes to be placed in a graduated series.

The irides of six March hares (three from Aberdeenshire and three from the far north of Scotland) varied greatly in colour. Three may be classed as light and three as dark. There are three February hares (two from Aberdeenshire and one from Ross-shire), two have dark irides and one a light iris (Ross-shire). The four October hares (two Ross-shire and two Aberdeenshire) had markedly different coloured irides; one was very dark (Ross-shire), one very light (Aberdeenshire) and two were of a moderate shade of brown.

Thus it will be obvious that if any change of iris pigment does exist, it could not be demonstrated on such small numbers, because the individual range, which gives hares of 1 and 16 and of 2, 10 and 19 in two several months (February and March), appears to be far in excess of the seasonal variation. The two November hares are very irregular and the two June hares equally out of order. It must be borne in mind, however, that the iris change, if it really exists, may lag on the coat change and the seasonal influence may be different in year, locality and individual. Without a very large number indeed of cases from each month it would be impossible by our first method to be certain that a slight seasonal variation does not exist, but this first method has certainly demonstrated the existence of a wide range of variation in the iris-pigmentation within the species. Of course our first method completely negatives any such complete change to an albinotic eye as Carron du Villards' note seems to imply.

The rest of the eye was examined from the point of view of any possible seasonal change in the pigmentation of parts other than the iris. The following remarks on the naked eye appearances are based on an examination of the Scottish hare's eyes already referred to.

At the free margin of the plica semilunaris is a band of brown pigment which does not alter with the summer or winter change of coat. A narrow band of brown pigment is present at the limbus conjunctivae, it sometimes completely surrounds the cornea, in other eyes it is absent at one or more places; of thirty-one eyes it formed a complete ring round the cornea in fifteen; usually the pigment is most conspicuous at the anterior and posterior parts of the horizontally oval cornea. Besides the variation in depth of colour of irides sometimes an individual iris is unevenly pigmented and there is usually a surface marking, conspicuous in many eyes, which has an irregularly diamond shape, the anterior and posterior angles of the diamond being situated nearer the root of the iris than the other two angles [Plate ζ, No. 6]. This surface marking has a deeper brown than rest of iris. These features make comparisons of depth of colour of irides more difficult. The pupillary margin is black. The fundus appears to vary in depth of colour as markedly as the iris; immediately below the optic disc is a definitely darker part of fundus which usually extends as a band anteriorly and posteriorly just below the bands of opaque retinal nerve fibres and has about the same breadth as these; after removal of the retina many little groups of branching choroidal blood-vessels can be made out with a magnifying glass in this dark band; a bluish line on posterior surface of sclerotic corresponds to its situation; choroidal vessels pass from upper and lower parts of fundus to the dark band; upper part of fundus is dark, but is separated from the band by a light part.

Microscopical Examination of eight of the eyes shows that the brown margin of the plica semilunaris is composed of pigment granules in the epithelium; there is no pigment in the stroma. The limbus pigment lies in the anterior epithelium, principally in the deep layers, it is in much greater quantity in some eyes than others; in the subepithelial tissue brown branched cells are present which may, to a slight extent only, assist in producing the pigmented band at limbus. The iris has very dark posterior layers and short spurs pass from them into the stroma at pupil region; the stroma pigment lies in branched cells and is mostly aggregated in anterior part of iris. A comparison was made of the microscopical appearance of light and dark irides with regard to the amount of pigment. No difference could be detected in the depth of pigmentation of the posterior layers, but in general the light irides had less stroma pigment than the dark ones; the iris with least stroma pigment was to the naked eye the lightest. The ciliary body has a dark epiblastic layer and has branched pigmented cells in the stroma, which is more pigmented than iris stroma. The choroid is well pigmented, pigment is arranged around the blood-vessels and interruptedly in front of these. The retinal pigment layer is dark brown, but is not so dark as the choroid. The site of the dark band seen macroscopically below the optic disc and opaque nerve fibres is marked by thicker choroid than the adjacent parts of fundus below it, also it is more heavily pigmented and is very vascular; in ordinary sections no difference in depth of pigmentation of retinal epithelium at the band could be detected. The sclerotic generally is not pigmented, although pigment accompanies blood-vessels as they pass through and there is pigment at entrance of optic nerve, most of this, however, is in the choroidal tissue. There is no evidence that there is any variation in pigmentation of these parts of the eye to correspond with the change of colour in the coat.

In an unusual specimen with white coat in summer (Plate ZZ, 183 and 184) the iris and fundus were normally pigmented. This was a male hare, shot on 12th of August 1910 by Major Fraser at Rhinstock, Aberdeenshire, and received on 16th August—weight 4½ lbs. when skinned and gutted; coat almost as thick as in winter; back and belly quite white[1]; small quantity of grey on dorsum of fud; hindlegs white with a few yellow-brown hairs on outer part and on dorsum of feet; forelegs white with exception of a few yellow-brown hairs on anterior part; ears are practically the only dark part of the animal, tip black, convex surface on anterior third is dark brown, middle third brown and posterior third white; concave surface dark brown posteriorly and light grey in other parts; face and whiskers white. Eyes soft; edge of plica semilunaris very lightly, if at all, pigmented; at limbus conjunctivae the merest trace of pigment to be made out, in neither eye does it form more than an isolated spot or two; iris uniform grey-brown, not particularly pale, not so pale as many irides; fundus brown, not abnormally pale; opaque nerve fibres present as usual. *Microscopical Examination:* iris has dark epiblastic layers and pigment in stroma in considerable quantity; ciliary body contains stroma pigment and has a darkly pigmented epiblastic layer. Choroid and retinal pigment layer are normally pigmented. The limbus epithelium has become separated which may account for the scarcity of pigment noted at this region.

Mention may here be made of a male foetus found in an adult hare on 15 April, 1910. Length of head 1¼″, breadth just behind eyes ⅞″, body length from brow to buttock 4″; coat bluish; belly pink; toes and nails well formed. Eyes: lids closed, but not adherent; pupil dilated; lens creamy yellow colour; iris dark blue-grey; no limbus pigment; fundus and ciliary body very pale. With the microscope no pigment found at limbus in epithelium or subepithelial tissue; iris has dark posterior layers, stroma a very few branched pigmented cells, not more numerous on anterior surface than elsewhere; choroid in its posterior part is nearly free from pigment, only a single cell with pigment is present here and there in some sections, further forwards the branched stroma cells of choroid become more numerous; retinal hexagonal cells are darkly pigmented; no pigment in sclerotic.

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[1] Microscopically, it is not different from winter coats of other hares; no granules (*vide Report*, Appendix A, No. 9) occur in the hairs.

(2) The second method to determine whether there is a seasonal variation in the colour of the iris, namely, the observation of two Norwegian hares' irides for twelve consecutive months was commenced on 9th December, 1909. At this date the iris of each hare was equally dark brown. Several Scottish hares' eyes preserved in formalin were compared with those of the living hares and one of the darkest which corresponded with theirs was marked for future comparison. Monthly examinations of the irides were made and no change was detected at any time. On August 14th, the animals being in full summer coat, the same shade of dark brown seen in December was found to be present when compared with the test eye. During September, October and November no change in colour of iris could be detected, either in the male or the female.

The observations on these two living hares did not lend support to any evidence derived from a comparison of the irides of dead hares, in favour of the view that there is seasonal variation in iris pigmentation. The irides of each of the young hares were dark brown like those of the parents, though perhaps scarcely so dark, and no change in colour was detected in the case of one of these young hares observed from July 1910 to May 1911.

It seemed possible that some help in this connection might be derived from a consideration of other animals which become white in winter, such as the stoat and ptarmigan.

SECTION III. *Examination of the Eyes of* Putorius erminea *at different Seasons of the Year.*

This animal is well known to change its summer coloured coat for a white winter one. Some winter and some summer specimens were obtained for the purpose of comparing the eye colour in specimens taken at these two seasons. A short description of the coat of each is given in Section VII below. The eyes of 17 stoats were examined macroscopically and in four of these animals a microscopical examination was also made. The 17 specimens were obtained in January, 1 specimen; February, 5 specimens; March, 4; April, 2; May, 1; July, 1; August, 1; September, 2.

Female Stoat, No. 3, *killed* 11*th February*, 1909, in Aberdeenshire, with winter coat. Eyes: iris dark brown; fundus dark; plica semilunaris has a brown free edge. *Microscopical Examination:* iris deeply pigmented in both mesoblastic and epiblastic portions, the stroma is most densely pigmented at anterior part where it forms, in the sections, a continuous very dark band broader than that formed by the posterior layers; much dark pigment is present at sclero-corneal junction throughout the entire thickness; at limbus the pigment is in long, irregular, branched cells, extremely little pigment in the epithelial cells, it is patchy; ciliary body and choroid heavily pigmented with dark pigment; retinal pigment layer well pigmented; sclerotic has pigment mostly at ciliary region where it is continuous with the pigment at sclero-corneal junction, and at entrance of optic nerve; pigment in plica semilunaris is confined to the epithelium at free margin from which it extends for some distance.

Male Stoat, No. 5, *received* 16*th February*, 1909, from Aberdeenshire, with winter coat. Eyes: iris dark brown; plica semilunaris has dark edge; continuous dark line at limbus; dark fundus. *Microscopical Examination:* iris exceedingly dark at posterior layers and also stroma, anterior part of stroma is so densely pigmented that it forms a continuous black band broader than the posterior layers; much dark pigment at sclero-corneal junction; no pigment found in anterior epithelium at limbus; ciliary body has very densely pigmented stroma and epithelial layer; retinal pigment layer dark brown; choroid except for the presence of blood-vessels is completely covered by dark pigment; sclerotic contains pigment at optic nerve entrance and in its anterior part at limbus; pigment in plica semilunaris is limited to the epithelium, there is none in the stroma.

Female Stoat, No. 15, *received* 9*th August*, 1909, from Aberdeenshire, with summer coat. Eyes: iris dark brown; limbus pigmented; fundus dark brown; plica semilunaris dark brown at free edge. *Microscopical Examination:* iris deeply pigmented in stroma and epiblastic layers; the stroma pigment is mostly aggregated at anterior part, it is very dark; much dark pigment at sclero-corneal junction; pigment scanty in anterior epithelium at limbus; ciliary body and choroid packed with dark pigment; around optic nerve entrance, in each section, are several dark pieces of pigment, but the sclerotic pigment is more plentiful in anterior part at corneal junction; retinal hexagonal cells well pigmented; pigment in plica semilunaris limited to the epithelium at free edge.

Male Stoat, No. 17, *received* 7*th September*, 1909, from Aberdeenshire, with summer coat. Eyes: iris dark brown; continuous dark ring at limbus; dark fundus; plica semilunaris with usual dark brown edge. *Microscopical Examination:* iris, epiblastic and mesoblastic portions very dark; much dark pigment at sclero-corneal junction as coarse branched pieces; very little pigment in anterior epithelium at limbus; choroid packed with dark pigment; retinal pigment layer dark; in sclerotic at optic nerve entrance are several pieces of dark pigment; plica semilunaris very darkly pigmented, only the epithelium contains pigment and the pigmented epithelium extends further from free edge of plica on anterior than on posterior surface.

One or both eyes of the remaining 13 stoats were examined macroscopically after exposing the iris by removal of the cornea and the fundus by opening the eyeball equatorially. The 13 stoats include winter and summer specimens and specimens with coats changing from winter to summer colour—Nos. 1, 2, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, all of which came from Aberdeenshire, except No. 8 (Selkirkshire), Nos. 10 and 12 (Morayshire) and Nos. 14 and 16 (Roxburghshire).

A comparison of these 17 stoats revealed no difference in the degree of pigmentation of the eye at different seasons. The iris, ciliary body, fundus and the plica semilunaris were as dark in winter as in summer specimens. The microscopical sections of winter stoats' eyes have as deeply pigmented mesoblastic and epiblastic parts as those of summer stoats.

There is evidence that other animals with seasonal variation of coat have no change in the colour of the eye. Dr G. L. Johnson says "The arctic fox (*C. lagopus*) to my great surprise showed no appreciable difference from other foxes. I examined him both with his brown summer coat and in his white winter coat, but the appearance of the eye remained the same[1]."

SECTION IV. *Examination of the Eyes of* Lagopus mutus *at different Seasons of the Year.*

In addition to the mammals described some British birds develop a more or less complete winter white plumage. In connection with the question of any seasonal change in the colour of the bird's eye we have examined ptarmigan (*Lagopus mutus*), a bird which changes a white winter plumage for a darker summer one. Two winter and two summer specimens were examined. All were shot in Aberdeenshire in 1909.

A. *Ptarmigan, female, received February* 18*th,* 1909, from Aberdeenshire. Plumage quite white except under tail feathers which are very dark and a few feathers on eyelids; lid margins brown; red eye-wattle. The sender of this bird says in a letter that he thinks ptarmigan are whitest in January although perfectly white specimens can be got a few weeks earlier or later; he adds "the female bird I am sending you seems as white as ever it had been." Eyes: iris very dark brown; fundus and pecten dark; no limbus pigment visible; narrow band of not very dark pigment at free edge of nictitating membrane. *Microscopical Examination:* iris has dark epiblastic layers; stroma pigment is dark and forms a broad continuous band at anterior part of iris; beneath this dark layer and usually connected with it are pigmented parts, more marked in pupil region than at root of iris, but apart from anterior part of iris there is not much stroma pigment; pigment present at sclero-corneal junction; no pigment in epithelium at limbus, ciliary body well pigmented; retinal epithelial layer brown; choroid heavily pigmented, its pigment is darker than that in retinal epithelial layer; pecten well pigmented with brown granules; brown pigment in sclerotic at posterior part of eye; pigment on outer part of sclerotic.

B. *Ptarmigan, male, received February* 18*th.* Feathers mostly white; under tail feathers dark; on back and under part of neck are a number of grey feathers and a few on eyelids; large red eye-wattle. Eyes: iris dark brown; no pigment at limbus; fundus and pecten dark; narrow dark band at margin of nictitating membrane. *Microscopical Examination:* iris posterior layers very dark; stroma pigment, as in last bird, chiefly confined to anterior part of iris where it forms a dark layer from which pigmented processes dip into deeper parts of stroma, also isolated pigment areas occur in the stroma; small quantity of pigment in epithelium at limbus; the pigmentation of ciliary body, retinal pigment layer, choroid and pecten is similar to that in the last bird. Pigment present on outer part of sclerotic.

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[1] *Phil. Trans. Roy. Soc.* Vol. 194, B, p. 19, Dec. 1901.

C. *Ptarmigan, shot August* 16*th, received on the* 18*th.* Feathers on head, neck and back silver grey with white points here and there; primaries and secondaries white with slaty shafts; under surface of wings white; belly and thighs grey; tail brownish grey, under feathers dark. Eyes: iris dark brown; no limbus pigment; fundus, pecten and ciliary body are all dark brown; nictitating membrane has narrow pigment band at edge; brown pigment on outer surface of sclerotic. *Microscopical Examination:* iris with dark posterior layers and stroma deeply pigmented in anterior part; numerous processes from dark anterior part of iris dip into deeper parts of stroma especially at pupil region, but also at root of iris; at limbus small quantity of dark pigment in epithelial layer; dark pigment at deeper parts of sclero-corneal junction; ciliary body well pigmented, the pigment is arranged in interrupted parallel rows in the stroma; epiblastic pigment layer very dark; choroid deeply pigmented; retinal pigment layer dark brown; pecten contains brown pigment and is darkest, as usual, at crest. Sclerotic pigmented at optic disc; pigment present on outer part of sclerotic.

D. *Ptarmigan, shot on August* 16*th, received on* 18*th.* Plumage similar to that of last bird although head, neck and back had a rather lighter shade of grey and belly and thighs were whiter. Eyes appeared to the naked eye to be of same colour as those of last bird except for a little pigment seen at parts of limbus and a description of the microscopical appearances would merely be a repetition of that already given for ptarmigan C.

In comparing the eyes of the two birds with white plumage shot in February with the two birds with summer plumage shot in August we find no gross difference in the degree of pigmentation. The iris in all of the birds was exceedingly dark brown, nearly black. The fundus was equally dark in each and no difference in depth of colour and amount of pigment at the sclero-corneal junction was found. A few fine differences need hardly be referred to, such, for instance, as the presence of a less dark and narrower pigment band at edge of nictitating membrane of A (winter) specimen than in C (summer) specimen whilst in B (winter) specimen and D (summer) specimen no such difference was noticed.

SECTION V. *Examination of the Eyes of* Larus ridibundus *at different Seasons of the Year.*

Another British bird that has marked seasonal change in colour of part of its plumage is the blackheaded gull (*Larus ridibundus*). The dark brown colour of the head which is so conspicuous a feature in summer disappears and is replaced by white in winter.

Immature winter specimen of blackheaded gull, received March 2nd, 1909, from Aberdeenshire coast; length $15\frac{1}{4}''$ from tip of tail to tip of beak; head white with the exception of a few brown feathers on eyelids and behind orbit and a few pale grey feathers on vertex; neck and breast quite white; back light blue-grey; tail feathers white with brown tips; wings under surface white to blue-grey; upper surface much blue-grey and dark tips and edges to the primaries; some of the lesser wing coverts are light brown; beak dull brown-yellow, brown at tip; feet and legs yellow-brown. Eyes: iris very dark brown; limbus unpigmented; ciliary body and fundus dark; inconspicuous band of brown pigment at free margin of nictitating membrane; pecten light brown with darker free extremity. *Microscopical Examination:* iris posterior layers dark; at anterior surface of iris is a continuous dark pigmented band; at pupil region in the deeper parts of stroma are branched cells containing brown pigment; processes pass from pigment layer at anterior surface of iris into stroma near pupil; no pigment found in other parts of stroma; at deeper parts of sclero-corneal junction is a quantity of dark pigment; retinal epithelial pigmented cells contain much brown pigment; choroid darkly pigmented; pigment of pecten is in groups of round brown granules.

Summer specimen of blackheaded gull, received July 20th, 1909, from Aberdeenshire coast; head and upper part of throat dark chocolate colour; neck and breast quite white; back light blue-grey; tail feathers white with yellow at tips; wing under surface white to blue-grey; upper surface much blue-grey and dark tips to the primaries; outer half of primaries white, inner half dark brown; beak and legs red. Eyes: iris brown of moderate shade, but dark in pupil region and at root, much lighter than dark brown iris of winter specimen; limbus unpigmented; ciliary body very dark; pecten light brown with darker crest; fundus dark; nictitating membrane has narrow brown band at free edge. *Microscopical Examination:* iris has darkly pigmented posterior layers; along anterior surface of iris, in some sections, is a continuous dark pigmented layer which in other sections is interrupted where pigment has obviously separated off; in stroma beneath this layer there is no pigment except near pupil where branched cells contain brown pigment; processes pass from pigment layer at anterior surface of iris into stroma near pupil; the pigment at sclero-corneal junction, ciliary body, pecten, choroid and retina is as plentiful and as dark as in the other bird. The lighter colour of iris in this bird may be explained by post mortem changes, for in one eye there was evident separation of the dark pigment in front of iris and in the other eye much dark pigment was present in the anterior chamber.

We believe that iris colour in this bird had been at all parts as dark as in winter bird before the separation of pigment.

Two other blackheaded gulls, received from same place on August 20th, 1910, had dark brown irides of the same depth of colour as that of the winter bird. Their heads were generally white though there were a few grey feathers.

From a comparison of the eyes of the summer birds with those of the winter bird no diminution of pigment could be shown to occur in winter.

SECTION VI. *Examination of the Coat of* Lepus variabilis *at different Seasons of the Year.*

Although references are frequently made to the change of coat colour in winter-white animals, yet few direct observations on living animals over any prolonged period seem to have been recorded. James Clark Ross says that a pair of arctic foxes (*C. lagopus*) kept for the purpose of watching the changes of their fur, threw off their winter dress during the first week in June; towards the end of September the brown fur of summer gradually became of an ash colour and by the middle of October was perfectly white[1]. From the same source is a description of rapid change in the coat of a Hudson's Bay lemming (*Arvicola Hudsonia*) and evidence that hares in captivity change their summer for winter coat colour[2].

Schwalbe[3] in a long and elaborate paper with bibliography discusses the subject of the change of coat in winter white animals and devotes attention chiefly to the stoat in which he found in autumn and spring a total change of most of the hair.

In the *Edinburgh Philosophical Journal* for 1820 it is said of *Lepus variabilis* that "about the middle of September the grey feet begin to be white and the ears and muzzle are of a brighter colour. The white colour gradually ascends the legs and thighs, and we observe under the grey hair whitish spots, which continue to increase till the end of October, but still the back continues of a grey colour, while the eyebrows and ears are nearly white." "By the middle of November, the whole fur, with the exception of the tips of the ears, which remain black, is of a fine shining white. The back becomes white within eight days. During the whole of this remarkable change in the fur, no hair falls from the animal: hence it appears, that the hair actually changes its colour, and that there is no renewal of it." In spring the hair is completely shed[4].

Macgillivray[5] from the examination of individuals at different periods of the year says of *Lepus variabilis*, "I have inferred that in this species the hair is almost always changing; that in April and May there is a general but gradual shedding, after which the summer colours are seen in perfection; that towards the middle of autumn many new white hairs have been substituted for coloured ones, and that, by degrees, all the hairs and under-fur are shed and renewed before the end of December."

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[1] James Clark Ross, *Zoology* in appendix of the *Narrative of a second Voyage in search of a North-West Passage and of a Residence in the Arctic Regions during the years* 1829—33, by Sir John Ross, London, 1835.

[2] *Ibid.* pp. xiii and xiv.

[3] Schwalbe, G., "Ueber den Farbenwechsel winterweisser Thiere," *Morphologische Arbeiten*, Bd. II., Jena, 1893, p. 483.

[4] *Edinburgh Philosophical Journal*, Vol. II. Edin. 1820, p. 191. (Note, not Vol. XI. as given in Welch's article cited p. 420 below.)

[5] *The Naturalist's Library*, Vol. XIII., "Mammalia" by W. Macgillivray, Edin. 1843, p. 284.

Welch[1] in 1869 says that *Lepus americanus*, represented by *L. variabilis* among the European species, for five months is clothed in white from December to April; two months are occupied by the autumnal change and one by the vernal. The winter's coat is generally carried in New Brunswick until the middle of May, when it is generally shed. He concludes that "the winter hue would appear to be brought about by a change of colour in the pile of the autumnal coat, combined with a new hybernal white crop, the latter undoubtedly playing no small part in the colouring process and in the thickening of the fur. There is no indication of shedding; an increase in length ensues over the whole body."

Mr J. Barcroft could find no trace of an autumn moult in the case of a Scotch variable hare kept at the request of Captain Barrett-Hamilton[2] at Cambridge under constant observation in the Physiological Laboratory during the autumn of 1899, and which had turned almost completely white by January, 1900. In the same winter a wild variable hare turned from half to almost completely white within the space of a few days in late December. The first half of the change had been accomplished earlier in the season.

The following notes based on observations on living and dead hares refer to but a few points in the wide subject of seasonal variation in the coat colour of winter white animals. Although the living hares were originally obtained by Professor Karl Pearson with the purpose of seeing whether the iris changed colour, some note was taken of the sequence of colour changes which occur in the coat, and an inquiry made into the question of whether a new crop of hair does or does not produce the change in appearance in autumn and spring.

Three hares were kept alive for a prolonged period and notes made from time to time of the appearances of their coats. In addition shot hares were obtained for each month of the year and their skins preserved.

Of the live hares a male and a female were received from Norway on 9th December, 1909, the former lived until 30th September, 1910 and the latter until 25th November, 1910. One of their young, born in July, 1910, was kept until 19th May, 1911.

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[1] Welch, Francis H., "Observations on *Lepus americanus*, especially with reference to the Modifications in the Fur consequent on the rotation of the Seasons, and the Change of Colour on the advent of Winter; based on Specimens obtained in the province of New Brunswick, North America," *Proc. Zoological Soc. of London*, 1869, pp. 228—236.

[2] Barrett-Hamilton, G. E. H., "Winter whitening of Mammals and Birds," *Proc. Royal Irish Academy*, Vol. XXIV., Dublin, 1902—4, p. 306.

A. *Norwegian Male Hare.*

9*th December*, 1909, coat generally white; back white with some grey over spine; belly white; neck white; feet white; hind legs white; forelegs white; ears, tips black, convex surface white mixed with some grey hairs, concave surface white; face white with two brown spots one on each eyebrow.

11*th January*, 1910, some grey on ears; generally as white as before; brown spot still present above each eye.

27*th February*, coat unchanged with exception of a splash on right side like hair matted with clotted blood.

28*th March*, back as white as on last examination; on right flank a brown-grey patch (Plate *v*, 2 and 4) measuring 5″ in length and 1½″ in breadth at anterior end, the broadest part, which is bifid; posterior end pointed; on left side of body is a spot with same colour, its situation corresponds to posterior end of patch on right side; belly, neck, fud and legs are white; right cheek has two streaky brown patches; nose brown; brown patches above eyes; when some white hairs were removed just in front of brown patch more brown hair was exposed, but a little further forwards no more brown hair was found; no trace of blood clot found. The splash seen on February 27 remained of same size for about ten days and then gradually got larger and browner suggesting summer coat.

8*th April*, left side almost quite white; face darker.

14*th April*, dark patch on right side considerably larger and depressed below white part of coat (Plate *v*, 5 and 6).

20*th April*, face brown all over; patch on right side of back is larger and a faint brown tinge is seen extending from the main dark patch over the back to left side where there is a brown tinge at upper part (Plate *v*, 7); generally, however, legs, belly and left side are still white.

24*th April*, coat brownish, but over vertebral column it is dark grey for a breadth of 4 to 5 inches; small darker patches are present at this region; on left side are a few isolated dark grey spots; remaining parts of left side, belly and legs are white; original brown patch on right side merges into and forms part of the dark area on back; original brown patch has a sharply defined lower margin and is darkest at anterior end; ears white with exception of black tips and brown roots; face brown, but not all parts, posterior part of left lower jaw is white and there is a patch of white on crown of head; a few long white hairs protrude from most parts of the coat; eyelids are pale and form a conspicuous rather broad lighter halo round the eyes (Plate *v*, 5, 6 and 7).

1*st May*, coat markedly darker, especially noticeable on left side; during past week a distinctly darker stripe has developed along the spine; ears becoming darker.

4*th May*, much darker last few days.

19*th May*, most of coat dark, but a narrow white stripe remains on right side of body; chest and neck are still white also the feet and most of forelegs; some white at ear margins; upper part of forelegs becoming brown.

27*th May*, belly becoming greyer; white at ear margins; whiskers white; white stripe on back unaltered.

30*th May*, fud white; eyelids light; white stripe on right side of back; legs generally white getting darker above; white edges to ears (Plate *ν*, 10 and 11).

26*th June* (Plate *ν*, 13 and 14), white hairs have disappeared from ears; legs now much browner (yellow-brown); white streak on right side of back unaltered.

11*th July* (Plate *ν*, 15), considerably darker than a few weeks ago; forelegs brown; white stripe on back present.

26*th July*, white stripe on back unaltered; upper eyelids nearly white; has white whiskers.

14*th August*, a systematic examination was made at close quarters. Back, neck and face grey brown; face of a more marked brown than back or neck; white stripe on right side of back still present; fud white beneath, brown on considerable portion of dorsum, edges light grey; belly whitish; hind legs brown externally, white on inner surface; hind feet mostly white, some brown on dorsal aspect; forelegs brown anteriorly, white posteriorly; upper surface of forefeet brown; ears, tips dark, convex surface dark brown, especially anteriorly, posteriorly they present a dark rather bald appearance, concave surface grey and baldish, posterior margin of ear white; eyelids pale; whiskers white (Plate *ν*, 17, 18, 19).

13*th September* (Plate *ν*, 20 and 21), whiskers white; back grey-brown with white stripe; belly grey-white; neck grey-brown, dorsal part lighter than other parts, it has also a bare and ruffled appearance; fud grey above, white below; legs and feet no apparent change since 14th August, the brown on hind feet is inconspicuous; ears, tip black, convex surface brown anterior third, grey posterior two-thirds, concave surface mostly grey, very dark towards posterior edge; face brown, lids darker than in August.

30*th September*, whiskers mostly white, some hairs are black, others black at proximal part and white at distal part; back, face, ears, fud and legs have not changed since 13th September. This hare died to-day.

B. *Norwegian Female Hare.*

9*th December*, 1909, coat not so white as that of the male; back and neck grey; belly, fud, hind legs and forelegs white; ears, convex and concave surfaces grey; tip black; face grey with some brown hairs; yellow-brown spot above each eye.

26*th December*, whiter generally than on arrival; face darkest about nose; darkness of irides conspicuous and in marked contrast to the white coat.

11*th January*, 1910, general aspect is grey.

27*th February*, no appreciable change in coat.

28*th March*, dark patch on right side (Plate *v*, 1 and 3) noticed early in March and thought to be blood clot, has been getting larger and is now found to consist of ordinary summer coat hair (grey-brown); the patch is situated between the spine and right shoulder, is roughly oblong with broader anterior end, length 4″, breadth 2″; on back, especially the posterior part, are some hairs similar to those on brown patch; isolated brown patch on left hip; coat generally has remained grey; fud, belly and legs white; neck grey; ears becoming brown in front; face markedly brown from muzzle up to level of eyes; brown spot above eyes extended so as nearly to surround eye. There seems little doubt now that the splash or "clotted blood area" assumed to be the result of injury was really the first appearance of summer coat, for it has since been occasionally found very difficult, by sight alone, to tell a blood clot matted area from a patch of summer coat, even on the skin of a dead hare and, besides, no trace of blood clot was found when the living hares were handled.

8*th April*, dark patch on right side of back is larger: over nearly whole length of spine is a broad tract of dark hair; right hip becoming dark; large dark patch on left side at upper part of back; small dark patch on left hip and a few small patches on back.

14*th April*, marked difference in coat, most of it is now brown (Plate *v*, 8 and 9); legs mostly white.

20*th April*, coat dark all over except on legs and belly which are still white; face is especially dark; someone who had not seen the hare before this date remarked that the colour suggested that the hare had been rolling in mud.

24*th April*, back uniform brownish-grey with blue tinge; belly quite white; legs white; face brown; ears, many white hairs on concave part; convex surface generally brown; a number of long white hairs project beyond rest of coat in most parts, fewest over spine; at both sides of anterior part of body and at back of neck the coat has fewer brown hairs and more white ones, also the long white hairs are numerous in this region which is shaggy and raised above the adjoining parts (Plate *v*, 8 and 9).

1*st May*, no marked change; feet and belly white.

19*th May*, coat dark; some white at ear margins; feet as white as on last examination; eyelids light and conspicuous, especially upper one, they form a circle that can readily be made out at a distance of even 30′.

27*th May*, belly greyish-white; ears white at edges; forelegs brown in front and at upper part; eyelids darker.

30*th May*, fud white; eyelids light; legs mostly white, getting darker above; white edges to ears (Plate *v*, 10, 11 and 12).

26*th June*, no white hairs on ears; legs much browner,—yellow-brown (Plate *v*, 14).

24*th July*, eyelids yellow-brown; no white whisker hairs.

26*th July* (Plate *v*, 16).

14*th August*, a systematic examination made at close quarters. Back, neck and face grey-brown, face browner than body; fud white beneath, brown upper surface with grey edge; belly greyish-white; hind legs brown externally, white inner surface; hind feet chiefly white, some brown on dorsal surface; forelegs brown anteriorly, white posteriorly; dorsum of fore feet brown; ears, tips black, convex surface brown, especially anteriorly, dark grey and baldish posteriorly, concave surface dark grey, posterior margin not white; whiskers dark; eyelids paler than surrounding coat (Plate *v*, 17, 18 and 19).

13*th September* (Plate *v*, 20 and 21), whiskers include a few white hairs; back brown, belly grey-white; neck brown; fud grey-brown on dorsum, white below; hind legs, forelegs and feet not altered since last month; ears unchanged, also face with exception of eyelids which are darker.

8*th October* (Plate *v*, 22—25), ears white at roots and at posterior two-thirds of convexity; forelegs dirty white with some brown; hind legs of snowy whiteness.

12*th October*, white parts of ears and legs are in marked contrast to rest of the coat; whiskers mostly brown; back brown, no change from September coat; belly white; neck brown; fud grey-brown on dorsum, white beneath; hind legs white except above, where external surface is still brown; hind feet white, with one small light brown spot on upper surface; forelegs white except upper part which is light brown; ears, tip dark, convexity has brown anterior third and quite white posterior two-thirds, concavity brown with large white patch just below tip. The white on ears has sharply defined margins well seen at root where white of one ear is distinctly separated from that of other ear; face brown; lids paler than rest of face; upper lip is lighter than it was last month. Viewed in profile the face seems to be dented in. The hair on lower part of nose is very short and where the longer hairs commence further up on front of face the curious appearance is produced.

19*th October*, changes since 12th October: (i) ears whiter at roots and on concave surface, (ii) legs whiter at upper parts, (iii) grey patch on right buttock size of a half-crown (Plate *v*, 24 and 25).

23*rd October*, coat generally, especially about buttocks, is greyer, but it is wet with rain.

26*th October* (Plate *v*, 26 and 27), whiskers no change; back generally dark with white patch on right buttock which has become larger and a small white patch has appeared just in front of fud; on left buttock a single small white spot; buttocks generally are greyer and white of belly is encroaching somewhat on the dark coloured sides; neck, besides white at base of ears, has isolated white patch at midline on dorsum, ventral part is more grey; fud generally white; hind legs and feet white, thighs becoming greyer externally; forelegs white, shoulders greyer; ears, tips dark, convexity white as to posterior two-thirds and now much white on anterior third of right ear only; concavity whiter especially anterior edge; lower part of nose has bare appearance and is nearly white at nostrils; lids no change.

2*nd November* (Plate *v*, 28 and 29), changes since October 26: (i) white patch beginning on left side, (ii) patch on back of neck has fused with white of ears,

(iii) thighs, especially right one, are whiter, (iv) more white on nose, (v) buttock much lighter, back is dark as formerly, (vi) front of neck is whiter, three or four isolated white spots, (vii) white spots on buttocks now form part of general light grey coat of that region ; anterior third of ear convexity remains mostly brown.

5*th November*, seen at a distance is distinctly grey all over both sides.

7*th November*, seen at a distance has piebald appearance ; white ring round eye connected by narrow white band with white patch behind ear on left side ; white at base of ears extends to anterior part so that a white ring is formed round base of ears; white spot on left side is larger ; on right of neck a white collar at upper part ; white spot on right side ; right thigh generally white, except for large brown patch continuous with brown of back ; nose whiter (Plate *v*, 30, 31 and 32).

9*th November*, back generally brown, though white of belly is extending up both sides and isolated grey or white spots are present all in the vicinity of the invading belly white ; buttocks white well up on to back. Face and body have piebald appearance (Plate *v*, 31 and 32) ; white ring round neck ; ventral part of neck splotchy ; fud white ; legs white ; ears, tips dark, convexity and concavity generally grey, some brown on anterior third of convexity ; white ring round nose connected by white band with white ring round each eye ; the hair of these white areas is shorter than the brown hair of neighbouring parts.

10*th November*, animal caught, coat has peculiar appearance. Back generally, and not buttocks, only is coated with a thick crop of short white hair of uniform length suggesting the sort of appearance produced in a newly-clipped horse or dog. In addition on the back are long dark hedgehog-like hairs which are very much longer than the general short white fur. These dark hairs stand up prominently and are remarkably scanty considering how dark the back appears where they are situated.

16*th November* (Plate *v*, 32 and 34), no conspicuous alteration. White on face has extended ; marked difference between the longer brown haired parts of face and the shorter white haired parts ; back is greyer.

23*rd November* (Plate *v*, 35 and 36), whiskers, a number of dark hairs ; back much whiter, brown chiefly limited to dorsal spine and even there brown hairs are scanty ; belly white ; neck, dorsum grey, white ventrally ; fud white ; hind legs white, grey on outer part of thigh ; forelegs white ; no brown on any of the feet ; ears, tips dark, convexity white with considerable quantity of brown hair on anterior third, concavity white except posterior edge which is grey-brown ; face white, nose brownish and crown brown, small brown spot above eyes in white area ; lids white.

25*th November*, found dead this morning. The brown patch on crown is diamond shaped, it is markedly differentiated from surrounding coat by the greater length of its hair and by the dark colour of the hair, while the neighbouring hair is white and much shorter[1]. The brown hairs on the patch are quite dark and show not the least evidence of bleaching. The dinted appearance of face in profile has diminished because the hair on lower part of nose is now longer. See Plate σ (3) for crown patch.

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[1] On December 22nd, 1911, E. C. Usher looked at 45 hares at a "drive"; all had a brown patch above the eyes, and 43 had brown hairs on forelegs.

On a comparison of the coats of the two hares the male was decidedly lighter than the female on 9th December, 1909, perhaps accounted for by difference in age—their age is not known. About the middle of January the female hare was still much greyer than the male. In the end of February the first signs of summer coat appeared in the male and a few days later in the female as a dark patch on the back. The change to summer coat by the end of March was more advanced in the female than the male, especially noticeable about ears and face. A week later the change in coat was distinctly more advanced in the female for she had largely changed to summer coat, while the male was still mostly white. By mid-April most of body coat of female had become brown and the brown patch on male's back had extended (Plate ν, 5—9). Even on 24th April most of the left side of body of the male was white and face less brown than the female's. By another week the male coat had become much darker particularly on left side of the body and ears; during the next few days it became still darker although even now lighter than the female. At this time, however, more than a glance was necessary to tell one hare from the other at a distance. At end of May (Plate ν, 10, 11, 12), coats both similar though male had the lighter one; legs of both generally white with a little brown at upper part. In another month, 26th June, legs of both hares much browner (yellow-brown) and white hairs had disappeared from ears. Throughout June and July the male remained rather lighter than the female; he retained a white stripe on back and had lighter eyelids (Plate ν, 13—16). In mid-August male was definitely, but not much, paler generally than the female hare; he had white whiskers and white posterior margins of ears not present in the female; other differences were considerably paler eyelids in male and retention of white stripe on right side of back; the female had retained no white spots on back (Plate ν, 17—19). During September no fresh differences were noted.

In the change from summer to winter coat in the female (the male died and had not begun to assume winter coat) the time occupied in change from summer colour to general white body coat lasted two or three weeks, from 23rd October to 10th November. The first sign of winter coat was seen on 8th October, it occurred on legs and ears and some days later on upper lip and right buttock.

During March, April and May the two hares were largely occupied in "mouthing[1]" their coats. The vigour with which this was sometimes performed was suggestive of an irritable condition of skin. A quantity of the hair is swallowed and passed in the faeces, for all the faeces examined on 8th April, from the hares' run, contained white hairs and most of the faeces gathered on 19th April on the hills on freshly fallen snow, and therefore recent specimens, also contained white hair. Further there were numbers of white hairs in the stomach and gut of a male and a female hare received on 15th April. These hairs were of varied size, some coarse and straight, others fine and wavy, and some partly pigmented. From the number of hairs found in the alimentary canal at one time and from the nearly constant presence of hair in the faeces there is little doubt that a considerable quantity of the hairs of the winter coat must thus be got rid of by licking. The Norwegian hares had largely given up "mouthing" their coats by 6th June. Hairs, however, are swallowed in summer time, though in less quantity, for in August some eighty of their droppings almost without exception contained hairs, but in scanty amount. The contents of the stomach and intestine of an August hare contained fewer hairs than in the case of the April animals. There are doubtless several ways by which the hare may rid itself of its superfluous coat, but "mouthing" and rolling on the back are the two which came under direct observation. In their natural habitat they may get rid of a lot of hair by contact with heather, for on hills where hares abound many bunches of hair were recovered in the spring of 1910.

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[1] This sporting term has been employed here because it is questionable whether this was merely a licking of the coat.

Offspring. This pair of hares had two families during the summer of 1910. The first family consisted of three (Plate o, 2). One leveret was seen on 4th June, a second on 6th June and the third on 13th June. No doubt they were born on the same day and had been hidden in a large bundle of sticks. They were very like each other as regards size, coat colour and iris colour.

Description of one of the young hares caught on 8th June.—Coat nearly uniform dark hedgehog brown; individual hairs are dark with light yellow points; back, sides, face and ears, legs and feet have same colour; black tip to ears; over the body are also a number of longer hairs which project fully $\frac{1}{4}''$ beyond the surface of rest of fur; belly light grey, and blueish grey where it approaches the brown part of coat; whiskers brownish. Eyes, lids lighter than rest of coat in this region, producing the appearance of a light ring round the eyes; pupils dark; iris dark brown; ophthalmoscopic examination: media clear; the two bands of opaque retinal nerve fibres are present as in the adult; refraction, low hypermetropia.

The second family appeared on 24th July, that is seven weeks after the first leveret was seen, and consisted of two. Both resembled in size and colour those of the other family when first seen. In August the coats of all the young hares with exception of being rather darker were essentially the same in appearance as those of the parent hares although the bellies were grey. One young hare had some white whisker hairs. They had lids paler than surrounding skin; the iris in all was dark brown; there was a marked similarity in the depth of brown in the iris of all the Norwegian hares young and old.

All five leverets thrived well and grew rapidly. One died on 30th August. Post-mortem examinations of this hare and the two adult Norwegian hares revealed no evidence of injury, all were well nourished, the adult female weighed $7\frac{1}{2}$ lbs., which was 2 lbs. heavier than any of several hares weighed at end of November (see below). In each animal the organs were normal to the naked eye and in no case was the cause of death determined. No signs of peritonitis were present.

Another of the young ones, kept for a prolonged period for observation, is the subject of the following notes.

C. *Male Norwegian Hare born July,* 1910 *in Aberdeen.*

This is one of the two young hares, seen for first time on 26 July, 1910, of the second family of the original pair of hares received from Norway in December, 1909.

The following notes were taken from 26th July, 1910, to 11th June, 1911, a period embracing the change from first summer to winter coat and most of the subsequent changes from winter to second summer coat.

Change of Coat Colour. See Plate o[1].

26*th July*, 1910, in size and colour similar to the three leverets of first family when they first appeared. Coat over back, sides, face, ears, legs and feet is of nearly uniform dark brown. The individual hairs are dark with light yellowish points producing a hedgehog-like appearance. On the body are a number of longer hairs which project quite $\frac{1}{4}''$ beyond the surface of the fur; tip of ear very dark; belly light grey and "blue[2]" where it approaches brown part of coat; whiskers brownish; eye-lids paler than adjacent coat giving an appearance of a light ring round the eye; pupils dark; iris brown (Plate o, 1 shows leveret, 1st family, June 26th).

13*th September*, back and sides brown, darker than those of parents; belly grey-brown; neck uniformly brown; fud brown, grey beneath; forelegs brown anteriorly, grey posteriorly; hind legs, inner surface grey, outer surface brown; ears[3], tip black; convex surface brown; concave surface grey-brown, dark towards posterior edge; face brown with lighter eyelids.

12*th October*, only change detected since last note is lighter appearance of upper lip; ears and legs not altered. The coat is perhaps rather lighter than that of adult.

19*th October*, legs becoming white.

26*th October*, whiskers turning white; back brown-grey, is distinctly lighter than adult; belly white encroaching more on darker sides and back; fud brown-grey; hind legs white with some brown; thighs like back; forelegs white, brown on dorsum of feet and on legs anteriorly; ears, tip dark, convex surface lighter on posterior two-thirds, but not white, concavity no change; face and eyelids no change.

2*nd November*, buttocks rather greyer; scraggy appearance of neck which suggests that hair is coming out; very little change all over since last note, face and back quite dark.

7*th November*, face becoming white; a patch of grey at each side of vertebral column far back.

8*th November*, seen at a distance[4] left side is dark; white noticeable at root of ear and posterior part of the convexity; small area of white at each side of nose; whitish feet and legs.

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[1] In Plate o an asterisk denotes the adult female hare.

[2] In Scotland the mountain hare is called the blue hare.

[3] In these notes the ear is described as having a convex surface divided into anterior $\frac{1}{3}$ and posterior $\frac{2}{3}$, a concavity and a tip.

[4] This is from 12 to 20 yards. The usual observations on the hares were made at distances from 6 to 15 feet.

9*th November*, back and especially buttocks are greyer though these are generally brown. Under certain conditions the coat looked much lighter, *e.g.* when the animal was moving away when a breeze was blowing from behind it and when body was stretched as he sat licking a hind foot the coat appeared remarkably lighter. Dorsum of neck grey; an incomplete grey ring around root of ears; fud brown-grey; hind legs white with brown on dorsum of feet; forelegs white; ears, tip dark; posterior two-thirds of convexity grey continuous with grey on back of neck; concavity grey; face brown, grey at sides of nose; eyelids grey.

16*th November*, no marked change during last week though it is perhaps generally lighter; not nearly so white as adult; brown remains on dorsum of forefeet.

23*rd November*, most hairs of whiskers dark; back greyer all over though still brown; grey on buttocks more marked; belly white; neck greyer, especially at upper part—root of ears,—posteriorly and at sides; fud white; hind legs and forelegs a little whiter; ears, tips dark, convexity whitish on posterior two-thirds, brown on anterior third, concavity whitish with brown at posterior edge; face, cheeks and root of ears whiter; lids whiter.

30*th November*, considerably whiter on back and sides, and especially buttocks which are almost quite white; brown hair on crown remains as a well-marked patch separated by white area from ears and by a light grey part from brown of nose; hair on this crown patch is longer than hair of adjacent white parts which produces a curious effect of depression of nose when viewed in profile; large white patch in front of each eye; ears show no further change.

7*th December*, back, sides and neck white or light grey, darker along spine; legs, belly and fud white; ears grey, anterior third of convexity brown and grey; brown hair of crown patch much longer than adjacent white coat.

14*th December*, back and sides light grey, nearly white, though appreciably darker than white of belly; darker brown over spine has disappeared; small amount of light brown on forefeet; face whiter; brown tuft on crown smaller; hair on body is longer and in places, *e.g.* on chest, is silky in appearance.

21*st December*, face distinctly whiter this week, noticeable around eyes and in smaller size of brown crown patch which is becoming encroached upon by white hairs from (*a*) nose, though lower part of nose is brown, (*b*) root of ears; body hair dirty white or light grey.

28*th December*, face whiter all along nose; brown crown patch smaller; no appearance of depression on nose now when seen in profile.

4*th January*, 1911, some light yellowish brown still present on forefeet; brown crown patch smaller from encroachment of white at upper part; white hair on nose below crown patch is longer than the brown hair of the patch.

18*th January*, brown crown patch distinctly smaller, white hairs present in its centre; ears have some brown hairs yet; white hair on body is long and more shaggy; very little brown on forefeet.

25*th January*, brown crown patch appreciably smaller and not so dark; white hair on nose below it is longer; white body hair is long and silky; few light yellow brown hairs on forefeet.

31*st January*, no change observed in face since last note; body coat has no dark patches, but is not quite white; nose has brown hair adjoining the mucous membrane; anterior third of convexity of ear is distinctly brown, and some brown, not much, in concavity; whiskers, most hairs dark; small brown patch on crown.

8*th February*, brown crown patch has become smaller and white hair on nose below it very long.

15*th February*, not much change; more white above eyes and white hairs on face are longer; belly is whiter than back.

25*th February*, at a distance the animal looks white except tips of ears, small crown patch and forwards on right side some light brown (seen for first time).

28*th February*, light brown patch on right side; white body hair very long; considerable quantity of coloured hairs on anterior third of convexity of ear.

6*th March*, broad light brown band at upper part of neck; face less white; nose below crown patch is darker; body unaltered; doubtful whether ears are browner at anterior third of convexity and in concavity; light brown hairs present on forefeet.

15*th March*, the only appreciable change since last week is the appearance of an inconspicuous yellowish brown streak, about 3″ long, on right lumbar region, its long axis lies antero-posteriorly.

18*th March*, brown band on neck broader, it extends further back; face darker; crown patch nearly continuous with brown on nose; brown streak in right lumbar region persists; small dark patch on right side below ear; colour of back and sides suggests that brown is very faintly showing through the white; legs unaltered.

22*nd March*, considerable change during last four days; brown round neck more obvious; nose darker; greyish brown, short hair from tip of nose upwards to crown patch from which it is separated by a few long white hairs; several black whisker hairs; grey-brown of ears more marked especially on convex surface; forefeet rather browner; back unaltered since last note; on left side a faint brown patch over shoulder joint; on right side a more marked brown patch is present at corresponding situation; brown streak in right lumbar region is darker and more defined; brown crown patch has spread in every direction, it has come nearer eyelids; small brown patch below left eye.

25*th March*, the suggestion of brown showing through the white of back and sides is rather stronger; brown patch at left shoulder not altered; on right side the dark brown streak in lumbar region is less noticeable owing to a large, diffuse, pale brown patch immediately below it; belly quite white; upper part of neck light brown; fud pale grey above, white below; hind legs white including feet; forelegs white, pale brown in small quantity on forefeet; ears, tip dark; convexity anterior third grey-brown, posterior two-thirds whiter; concavity has white margin and is generally white with dark patch near margin posteriorly; brown on face is continuous from point of nose to white at root of ears; upper lip brown, from it to angle of jaw the hairs are brown with small quantity of white hair interspersed; eyelids white; white ring round eye has become more conspicuous; at a distance or in twilight the hare looks quite white, except the head which is obviously darker.

29*th March*, right side and neck distinctly brown; left side no appreciable change; face darker; a few remaining white hairs at site of lower border of former crown patch are long and project beyond the neighbouring brown hairs.

1*st April*, little change; mark conspicuous on right lumbar region; sandy coloured ring round neck; some white remaining at ear roots and base of nose, but not much.

5*th April*, animal looks less plump; dark streak on right lumbar region more marked; light brown patch immediately below it; light brown patch at corresponding situation on left side; light brown patch on each shoulder; face nearly all brown, some white round eyes; legs unaltered; light brown broad band round neck; body, however, is mostly white though the brown tinge generally is a little more evident.

8*th April*, coat darker all over, whitest on dorsum except just along spine; two definite large coloured patches on left side (1) over shoulder, (2) over hip joint; right side has coloured patches (1) on shoulder, less marked than that on left side, (2) on hip extending short distance down thigh, (3) streak in lumbar region which is darker, but no longer. These patches, excepting lumbar streak, are light yellowish brown; coat between the patches has faint tinge of brown; forelegs unchanged, yellow brown on feet slightly more marked; no brown hairs on hind feet, which are quite white; ears show much white; edge of concavity has much long white hair, grey mixed with brown in concavity; convex surface brown interspersed with a quantity of grey; posterior two-thirds lighter than anterior third; tips dark; face generally brown; white ring round eyes; white extends backwards for short distance from this ring; back of neck ragged and grey.

9*th April*, seen at a distance, white at root of ears is conspicuous; the four coloured patches on body are larger and cover about a half of each side.

12*th April*, not much change; neck yellow brown; two darker, small, streaks over spine posteriorly; streak on right lumbar region not altered.

15*th April*, coat considerably browner, could no longer be called white; nape of neck brown; sides between shoulder and hip much darker; white patch behind eyes, on left side it is separate from the white ring round eye, on right side it is continuous with it; bases of ears darker; darker grey-brown on anterior part of convex surface of ears; lumbar dark streak on right side less conspicuous; feet and fud unchanged.

22*nd April*, coat generally darker, yet when seen at a distance cannot be described as either a summer coat or as a winter coat. No patches on back and sides, but differences of shade which gradually merge; the darkest parts are over backbone posteriorly and above forelegs; not so shaggy at nape of neck; brown surrounds base of ears; convex surface of ears browner at anterior third; at posterior edge of concavity is a darker area; face has nearly complete summer appearance, except posterior to and around eyes where coat is still light; whiskers dark; legs nearly quite white, no apparent change to summer coat; fud no change.

26*th April*, coat considerably lighter than ordinary summer coat, darkest parts are down front of face and over spine and, of course, tip of ear; all legs nearly quite white, a commencement of dark hair on extensor surfaces at upper part continuous with coloured hair on body; the white hairs on legs and at ear margins are long.

29*th April*, dark hair has extended much further down extensor aspects of legs; on front of forelegs some faint brown parts are visible; ears generally less white; coat still very light, though darker, is not patchy; fud darker on dorsum, end of it white; on body much loose white hair in tufts here and there, mostly about neck.

6*th May*, coat becoming darker, especially along spine and at shoulders; fud, summer colour on dorsum; legs mostly white, upper parts more coloured; posterior two-thirds of convexity of ears are light.

14*th May*, coat again darker; darkest parts are front of face, root of ears and tip, and along spine and on shoulders; it is now a summer coloured coat with considerable amount of grey at buttocks and at two shaggy places on upper part of neck; ears, convexity, posterior two-thirds darker, a quantity of white remaining, anterior third summer coat; concavity has a quantity of white hair; face brown with pale yellow ring round eyes; whiskers, upper hairs dark, lower ones white (seen at 5′); belly white; fud white below, summer coat colour above; hind legs white on flexor aspects, summer coat extends down their outer sides from body; hind feet white; forelegs white on flexor aspects, summer coat extends from body down extensor surface, light brown parts beginning lower down and on feet.

19*th May*, ears much less white; hind feet quite white; brown on forefeet increasing; lids darker; coat generally darker.

11*th June*, a good deal of white about the feet, on lower part of hind legs and I think inside the ears[1].

The changes which occurred in the coat on any one part of the body of this hare have been tabulated and a series of consecutive photos reproduced. In the table no column is provided for tip of ear which remained dark throughout the year or for whisker hairs which sometimes, at the usual distance of observation, could not be sufficiently well seen for our purpose.

It should be remembered that some of the changes in the coat recorded on certain dates may not be visible in the photographs of these dates, although they may be seen in photographs of later dates when the recorded changes have become more manifest.

The photographs were taken at distances ranging from five to twenty feet. Most of them were taken in the morning and necessarily in different conditions of light and weather. A number of photographs are necessary to give an adequate picture of the gradual changes. It is probable that some darker parts of coat, seen in some photographs and not mentioned in the notes, are caused by the arrangement of the hairs, *e.g.* when the animal is wet, and not by darker hairs. Naturally the coat appears lighter or darker in some photographs than it really is, because of the varying light conditions.

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[1] Letter from E. Nettleship 11 June, 1911, who now has this hare.

The change in coat colour of this hare has been very gradual and beginnings of summer coat appeared perhaps even before the change from summer to winter coat had quite ended.

The first sign of winter coat was seen on upper lip on 12th October, then legs showed signs on 19th October, sides of body and ears on 26th October, neck on 2nd November and face on 7th November. The face did not become completely white, there remained (1) a small brown patch on crown, (2) a pale brown spot above the eye. The forefeet were never completely white although the pale brown was seen with difficulty even at the short distance of a few feet.

As indicated, the changes from summer to winter coat were still being looked for, particularly on the head, at the end of February when the beginning of the summer coat appeared. The first sign of summer coat was seen on right shoulder on 25th February, then face and neck showed signs on 6th March, ears on 22nd March, legs on 26th April and fud by 29th April. The ears and legs remained white later into summer than other parts. The legs, especially the hind legs, on 19th May had a considerable amount of white on parts that become brown in summer. The dark streak on right lumbar region resembled the elongated patch on the right flank of the male parent. This young hare never became so white in winter as its father. About six weeks elapsed between the time that the body coat would still be called white and the time that it would be called summer coat, and approximately the same interval occurred between the latest period that the body coat would be termed "summer" and the time it could at the earliest be called white.

With regard to the reputed influence of weather conditions on the change of coat colour it will be seen that no sudden change occurred in this hare at the onset of cold weather or after the first fall of snow. The daily meteorological record of the City of Aberdeen from observations at King's College Observatory from January, 1910 to April, 1911[1] shows the daily mean of highest and lowest temperature of atmosphere, and the days on which snow and hail fell, with amount, to be as follows:—

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[1] From Report of Medical Officer of Health, City of Aberdeen.

Temperature of Atmosphere.

Mean of Highest and Lowest.

Day of Month	January, 1910	February, 1910	March, 1910	April, 1910	May, 1910	June, 1910	July, 1910	August, 1910	September, 1910	October, 1910	November, 1910	December, 1910	January, 1911	February, 1911	March, 1911	April, 1911
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1	46·4	38·3	37·2	44·6	55·0	50·5	52·1	57·7	54·9	51·6	40·3	38·8	40·1 S.	33·9	42·7	38·8
2	49·3	39·2	44·5	39·6	47·5	49·6	51·4	55·7	55·5	57·7	38·6	41·6	39·8	37·5	46·2	40·7
3	47·7	36·5	43·3	39·8	43·3	51·9	53·8	57·8	53·6	52·4	39·8	42·7	34·7 H.	42·8	49·0	36·3 S.
4	42·2	36·8	40·5	40·9	44·6	47·4	56·1	56·3	52·2	58·7	40·5	42·5	35·7 H.	42·2	42·2	37·0 S. H.
5	42·2	41·3	40·3	41·5	43·2	45·5	51·9	57·1	50·9	60·5	38·4	46·0	39·6	37·6	40·2	35·1
6	36·6	41 9	42·5	42·9	43·3	50·3	52·8	55·5	52·4	57·0	38·2 H.	46·4	37·9	39·5	41·6 H.	37·6
7	40·8	36·7	44·3	39·8	43·7	51·4	52·8	57·7	51·1	51·5	37·7 H.	42·6	36·7	39·2	38·9	43·1
8	43·8	33·4 S.	44·6	39·7	40·6	50·6	51·7	57·7	49·9	50·2	39·2 H.	42·1	42·9	35·5	43·4	43·8
9	44·7	34·1	45·1	41·4	41·6	51·2	51·5	57·0	50·9	45·7	37·1 S.	46·5	38·1	37·7	40·0	45·3
10	37·5	41·8	42·5	46·4	42·9	57·6	55·6	55·1	55·8	46·6	33·8	47·0	39·9	37·1	40·3	40·4
11	34·3	38·3	39·4	46·3	46·7	57·0	52·5	54·4	53·1	49·5	35·6	47·3	37·2 S.	37·0	39·7	42·6
12	33·9 S.	37·8	37·8 S.	46·7	45·0	56·0	51·9	60·5	50·1	47·3	37·4	46·3	33·6 S.	34·8	37·6 S. H.	43·2
13	35·5 S.	44·3	37·2	41·3	47·2	54·8	52·2	58·4	51·5	46·3	44 0	46·4	35·0	43·4	36·9 S. H.	45·1
14	41·6	39·0	40·1	43·7	52·7	53·3	52·0	56·9	51·0	46·1	43·3	46·5	37·6	44·9	37·0 S. H.	49·0
15	39·2	36·8	40·4	37·7	53·5	52·7	53·1	54·5	49·7	45·6	37·3 S.	45·9	37·7	40·4	40 1 H.	48·2
16	41·7	35·5	47·4	37·0	52·8	54·6	52·1	57·2	51·3	49 8	35·6	44·1	40·2	48·0	39·7 H.	42·8
17	38·6	42·5	37·1 S.	40·0	46·3	55·3	52·1	60·0	53·1	47·0	38·9 H.	42·9	45·6	46·2	40·2 H.	39·5
18	34·5	42·0	33·0 S.	44·3	46·0	52·2	52·5	59·1	51·5	46·4	38·6	40·9	45·1	47·0	37·1 H.	47·5
19	35·0	41·0	41·0	46·2	47·8	52·5	52·3	59·7	46·5	46·0	31·5 S.	43·9	36·9	36·9 S.	36·2 H.	45·6
20	33·7 S.	42·1	48·2	43·2	50·6	54 4	55·9	57·8	46·6	46 6	32·9 S.	42·5	38·6	33·2 S.	37·5 S.	45·9
21	30·1 S.	40·6	43·6	42·6 H.	48·6	55·6	58·0	52·9	52·3	52·7	36·8 S.	41·4	39·1	41·4	38·9	49·3
22	29·6 S.	37·4 S.	44·4	38·8 S.	50·7	56·5	57·8	51·2	52·7	51·4	34·0	43·6	38·9	45·5	39·8	56·0
23	25·6 S.	37·0	48·0	45·1	53·4	54·9	51·4	50·2	60·4	49·9	35·0	50·2	38·9	45·6	38·0	53·6
24	33·1 S.	36·2	48·4	42·8 H.	47·2	51·2	49·5	54·9	51·1	49·9	42·5	46·2	42·7	39·8	39·5 H.	52·2
25	27·0 S.	37·5	45·3	41·9 H.	47·3	51·5	52·9	53·5	53·9	49·9	42·6	39·8	44·5	40·4	39·5	53·4
26	16·3	34·8	45·1	41·8	57·1	49·2	55·1	55·3	54·1	50·1	40·1	35·4 S.	42·2	38·4	41·6	46·2 H.
27	18·0 S.	37·1	43·4	43·9	53·5	50·9	52·3	56 5	54·5	49·9	39·9	32·4 S.	41·9	37·3	41·2	44·6
28	21·3 S.	36·2	43 0	42·3 H.S.	55·9	48·5	57·1	54·7	54·9	48·5	38·0	35·6 S.	40·0	45·2	41·2	45·2
29	34·8 S.		44·9	42·2 H.	51·9	52·5	55·8	56·2	51·8	45·9	37·2 S.	40·2	43·5		41·3	43·1
30	35·8		44·8	44·6	51·1	52·7	56·3	57·3	51·2	43·5	37·3	39·6	41·3		40·7	44·0 H.
31	39·3		42·7		51·3		59·0	55·9		42·7		41·8	35·1		42·2	
Mean	35·8	38·4	42·6	42·3	48·5	52·4	53·6	56·3	52·3	49·6	38·1	42·9	39·4	40·3	40·3	44·5

S. = Snow, H. = Hail.

Twelve Scottish hare skins obtained one in each month of the year (Plates YY^a and YY^b). The hares were all shot in Aberdeenshire and all were killed in 1909 except the April hare which was got in 1910.

The *January* hare has a dirty white back with some brown hairs over spine; neck same as back; belly and fud white; hind legs white with a few yellow-brown hairs on anterior aspect; forelegs are white with some yellow-brown hairs on anterior aspect; face generally is white with light brown at end of nose and brown patch above each eye, and some brown below eye and on crown of head; whiskers, ventral group white, dorsal group black; ears: tip black, convex surface brown anteriorly and white on posterior two-thirds; concave surface has a mixture of white and brown hairs.

The *February* hare has less brown below the eyes and rather more on crown of head, but in other respects has the same appearance as the January one.

The *March* hare has the same appearance as the last two hares as regards back, neck, belly and fud; forelegs white with a few brown hairs in front; hind legs are quite white; both groups of whisker hairs are white although individual hairs are dark at base; face has same appearance as February hare—(note in photograph that on left side of belly a large patch is caused by blood-clot); ears: black tip; convex surface brown at anterior part, white at posterior part; concave surface white and hairs are scanty.

The *April* hare's back is mostly grey, although there are several brown patches most numerous about the saddle and three isolated small brown patches on right side—(note in photograph that on left side of belly is a depressed patch caused by blood-clot); belly white; neck grey; hind legs white; forelegs white with brown hairs anteriorly: face is much browner than those of the three previous hares, all between the eyes is brown; on crown some grey hairs amongst the brown ones; more brown below eyes than had the March specimen: whiskers: both groups of hair are white and the black at basal end of individual hairs occupies a larger part than in last hare; ears: black tip; convex surface white on posterior two-thirds and brown on anterior third; concave surface white with some brown hairs.

The *May* hare has a uniformly brown back which becomes lighter towards belly; dorsal part of neck is brown, ventral part grey-brown; belly dark grey; fud grey; marked large brown patches on hind legs; forelegs uniformly brown; face brown all over; lids paler than rest of face; whiskers: some hairs are black, the longer hairs are white at tip or are nearly all white; ears: tip black; convex surface dark brown all over; concave surface has a few white hairs.

The *June* hare has brown back; grey belly; darker brown neck than May hare; fud grey; hind legs of a uniform light brown; forelegs brown; face markedly brown all over; lids rather lighter; most of whiskers black, some hairs in ventral group are white most of their length although all are dark at the root; ears: tip black; convex surface dark brown, concave surface grey and brown at posterior edge.

The *July* hare has brown back and neck; grey belly, part is lighter than in June hare; fud grey above, white beneath; forelegs brown; face brown; eyelids paler than face; whiskers same as in June hare; ears: tip black; convex surface brown; concave surface brown with some grey.

The *August* hare has brown back, neck, hind legs and forelegs; belly grey, whitish below; fud grey on dorsum, white beneath; face dark brown; whiskers have more white hairs than in July hare and few of the white hairs are pigmented at root; ears: tip black; convex surface brown at anterior third, the rest grey-brown; concave surface brown with some grey.

The *September* hare has a rich brown back; belly whiter than that of August hare; neck brown; fud grey on dorsum, white beneath; hind legs have much white hair amongst the brown; forelegs, much darker than hind legs, are brown anteriorly and white posteriorly; face dark brown with small white patch on crown; whiskers similar to August hare, one of the hairs is white only at middle of shaft; ears: tip black; whole of convex surface dark brown; posterior edge grey-white; concave surface brown. (Note in photograph that fud is partially detached and appears whiter than in reality.)

The *October* hare has a much lighter back than the September hare and the white of the belly is encroaching on the sides more than in that hare; neck grey with a few brown hairs; fud whiter on dorsum than in last hare, white beneath; hind legs white with a very little brown; forelegs white with more brown hairs than on hind legs; face lighter brown than that of September hare; most of the hairs in whiskers are white, none are black in all their length, although a few are dark at the root; ears: tip black; convex surface brown with white posterior part; concave surface brown; are generally much lighter than in last hare.

The *November* hare has a white back with a few dark hairs; belly white; neck white with a few dark hairs on dorsum; fud all white; hind legs white; forelegs white with scanty light brown hairs on anterior surface; face white with exception of a very small light brown patch above each eye and at tip of nose; whiskers black, one or two hairs are white; ears: tip black; convex surface brown at anterior third, the rest is white; concave surface grey with some brown hairs. (Note in photograph that dark spot on back is blood-clot.)

The *December* hare has the same appearance as the November hare as regards back, belly, fud and legs; neck is white; face white with exception of a light brown patch above the eyes and at tip of nose; whiskers white, a single black hair; ears same as last hare. (Note in photograph that two dark spots on posterior part of back are from blood.)

In none of the skins are the whisker hairs entirely of one colour, and although it is noted more than once that the captive hares had "white whiskers" it is to be remembered that it is not possible at a distance of even a few feet to determine that every part of each hair is of one colour.

The November skin would seem to be exceptionally white for the time of year, as it is whiter than the skins of eight hares shot at the end of November, 1910. These skins were all from the same district as this November skin and were very like each other. All these hares were thin as there had been much snow on the ground for the previous four weeks. They were principally white or grey excepting face and ears; all had white at root of ears as will be seen in these tabulated notes of six of them.

27 Nov. 1910	Back and sides	Belly	Fud	Ears				Face	Forelegs	Hind legs	Iris	Weight
				Tip	Convexity		Concavity					
					Anterior $\frac{1}{3}$	Posterior $\frac{2}{3}$						
Hare 1	Changing, mixed brown and white; brown hair longer than white	white	white	black	brown	grey	brown	brown except white root of ears; lids with short white hair; grey at side of nose	white, paws brown on dorsum	white	pale brown	$5\frac{1}{2}$ lb.
Hare 2	Grey with much brown especially over spine; some patchiness, but not marked; neck same as back	white	white	black	brown	white	brown	brown except white root of ears and grey lids; whiskers, most hairs white	white, a little brown anteriorly	white	pale brown	$5\frac{1}{3}$ lb.
Hare 3	Grey with some brown; some darker parts	white	white	black	brown	grey	brown	brown; large white patch in front of eye; complete circle of white at root of ears; lids grey-brown; small tuft of white on crown; whiskers, most hairs white	white, some brown on anterior surface	white, some brown on outer surface	medium brown	$5\frac{1}{3}$ lb.
Hare 4	Grey-white over spine, the rest white except patches of brown, (1) each side of neck, (2) between shoulders, (3) low down on left side	white	white	black	brown	grey	brown	complete ring of white round base of ears; grey all round eye with brown spot over eye; white in front of eyes and on dorsum of nose, white hairs shorter than the brown; marked brown diamond shaped patch on crown is without any bleached hairs	white, brown on paws	white	pale brown	$5\frac{1}{3}$ lb.
Hare 5	Grey from spine down some distance on sides; rest white	white	white	black	brown	grey	brown	generally brown except (1) root of ears, (2) from ear roots forwards to ring round eye and again forwards towards tip of nose; these parts are quite white with very short hairs	yellow-brown on anterior surface, rest white	white	fairly dark brown	$5\frac{1}{2}$ lb.
Hare 6 (Skin only)	Grey with brown over spine	white	white	black	brown	grey-white	brown	brown except white at root of ears; whiskers, most hairs white	white, with brown on anterior surface	absent	—	—

Hair. A. Tufts of hair were removed from the dorsum of each of the twelve hares of the series and their structure noted. In each case the main bulk of a tuft consists of fine wavy hairs beyond which the distal parts of stout, more bristle-like hairs project. In a summer tuft three zones can be distinguished, the proximal one is pale grey, the middle one has a pale yellow-brown tint, and the distal one, which is not so compact as the other two, is very much darker; the distal zone is composed entirely of the bristle hairs[1]. In a winter tuft the middle and distal zones are quite white, and the length of a tuft is greater than that of a summer tuft. No structural difference was seen in the wavy hairs of the summer and the winter coat[2], but in the case of the bristle hairs, the summer ones were mostly bristle-like throughout their length, while the winter bristle hairs were bristle-like only in their distal part, the rest of the hair being thin and wavy, like the other form of hair. Examination of winter hairs[3] shows them to be white throughout, but the summer bristle hairs are brown with a paler part a short distance from the pointed tip, which gives to the coat a hedgehog or porcupine-like appearance. Some of the summer bristle hairs are thin at their attachment, others are thin and wavy, but the wavy part never forms such a large proportion of the hair as in the winter bristle hairs. In any winter coat scattered long dark hairs can always be found. In March and April skins numerous short pigmented bristle hairs were present, though not visible until the long white winter hair was separated. Similarly in October hares on separation of the summer hair large quantities of short white bristles were seen. In one October hare these were not visible on the dorsum, but were found in the flanks.

B. From the live female Norwegian hare a tuft was pulled out on 10th November, 1910, from a brownish area on the dorsum. Its basal part had a grey appearance, its smaller distal part consisted entirely of dark hairs, total length 27 mm. On closer inspection most of the proximal portion was found made up of fine wavy white hairs amongst which was a large quantity of stout white pointed bristles which extend the whole length of the basal part under consideration. The distal part is formed by dark bristles which are much larger than the white ones just mentioned. The pigmented bristles when traced were found to be thin and wavy towards their attachments. A second tuft was taken on the same day from the buttock, which was white. It resembled the other tuft except that there was no demarcation of the distal part, although a few stray dark bristle hairs projected from the surface. This tuft was 22 mm. in length, while the proximal portion of the first tuft measured 18 mm. in length. This buttock tuft also consists mostly of fine white wavy hairs, but there are large numbers of pointed white bristle hairs, a few of which have some pigment at point, at base or at both. The few coloured bristle hairs projecting beyond the tuft are attached to an exceedingly delicate wavy proximal part. A third tuft, from the side, exactly resembled the buttock tuft. These tufts consisted of the whole length of the hair.

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[1] These have large and plentiful granules. See Appendix A to this chapter.

[2] The former contain both diffused and granular pigments. The diffused pigment is a bright yellow-brown, and the granules are fairly large and quite plentiful. The wavy hairs of the winter coat contain no granules. See Appendix A.

[3] Winter bristle hairs are quite free of granules. See Appendix A.

In the hare shortly after birth, the coat on close inspection has a nearly uniformly dark brown hedgehog-like appearance. Individual hairs are dark with light yellow points.

From the adult male Norwegian hare a tuft removed from a brown patch on back on 28th March, 1910, is generally brown darkest near free end, and blue-grey at denser attached end. Two kinds of hair are distinguishable, (*a*) a stout, brown, well pigmented, bristle-like hair, darkest at a short distance from the tip, (*b*) a finer, more wavy and less pigmented hair, without a darker part near free end. The blue-grey appearance at base of tuft is chiefly produced by these finer hairs. Another tuft removed on the same day from the white back of the same animal is pure white, is denser at attached end and is composed generally of long fine wavy hairs with a rigid bristle attached to the distal end of some. The wavy part of a hair is much thinner than the bristle part. The bristle is about $\frac{1}{4}$ the length of the whole hair, but the proportion varies. A few very long bristles are present without any wavy proximal attachment. When the white hair was removed from the animal at edge of the brown patch no more brown appeared except close to the patch.

The observations on the living hares and the examination of the Scottish hare skins show that while the main winter to summer change is a comparatively rapid one, which occurs in March and April and in the case of the Norwegian hares lasted from two to four weeks in the adults and six weeks in the leveret, there are other, less obvious, changes which precede and follow the main change. Thus there were slight signs of summer coat in the captive hares for several weeks before the main change, and for months afterwards minor changes were taking place, such as colouration of legs and ears and general darkening of the coat. The earliest change of all occurred in the three hares on right side of body as a defined patch which appeared late in February or early in March. The next change was seen on left side of body and on the face. The main change at first consisted in a mere suspicion of brown showing through the white on the body generally, this gradually became more pronounced until the summer coat was assumed. The ears and legs retained their winter whiteness longer than the rest of the coat, thus on 30th May these parts had white on them in the male adult, and not until 26th June were the ears noted as having "no white hairs" and legs as "much browner."

Similarly the main change from summer to winter is comparatively rapid and occurs in October and November, and in the Norwegian hares lasted about three weeks in the adult and fully five weeks in the leveret. As in the vernal change less obvious changes occur before and after the main one. The earliest change occurred in the upper lip and in the parts that remain longest white in the spring change—the legs (both hares) and also ears (one hare). These changes were noticed on October 8th and 9th. The main change is a gradual greying of the buttocks and of the body, beginning on the sides low down, and extending upwards towards the middle line. The grey becomes lighter and finally white. Some brown remained on the face of the leveret throughout winter, and when the adult died at end of November she had a considerable quantity of brown on her face. The change from winter to summer coat and summer to winter coat apparently, therefore, takes place in definite order.

The dark tip to the ear is a well-known constant feature, in addition to this there is a small light brown spot above each eye present on all our winter skins, even the whitest, although not present in the anomalous white August hare; and in all of the hares some brown was present on forefeet throughout winter. This would suggest that for this latitude, 57° 9′, the brown spot above the eye and the brown hairs on forefeet are constant features[1]. Giebel[2] gives the following sentence in describing *L. variabilis.* "Im Winter wird das Colorit rein weiss bis auf die schwarzen Ohrspitzen und gelblichen Pfoten." He does not say whether the coloured hairs were present on all of the feet or only on the forefeet.

Although the change in coat may occur earlier in some hares than in others, *e.g.* in the Norwegian hares—the female became darker sooner than the male—and whilst hares which we have received on the same day showed some difference, yet it does not appear that there is any wide range at a particular time. There was very little difference in the appearance of eight hares seen at the same time in November. It is recorded, however, that some Alpine hares were killed in the last week of October, which had not in any degree changed the colour of their dark summer fur, whilst at the same time others were almost entirely white[3]. Anomalies of coat colour occur as is seen in the coat of a Norwegian hare with a white patch which was retained throughout summer and in a white coated Scottish hare obtained in August. This latter is very unusual as several naturalists and gamekeepers with wide experience of hares at all seasons have stated that they have never seen or heard of such. We have no knowledge of a summer coated hare in winter. Beddard says the Alpine hare in Scotland generally becomes white in winter[4]. The Irish hare (*L. hibernicus*), considered by Thompson to hold in several respects an intermediate place between *L. timidus* and *L. variabilis,* does not periodically assume a white garb[3]. Johnston says that ordinarily the mountain hare in Ireland only turns a somewhat bluer-grey in the winter and that the change to complete white is never known to occur. The utmost amount of white recorded in the winter change is represented by the author's drawing from a very rare example in the Natural History Museum, Dublin. In this case the face and a broad band along each side of the back remained greyish-brown, whilst the rest of the body became white[5]. Millais on the other hand states that a considerable proportion of these hares (*L. timidus hibernicus*, Yarrell) in Ireland do turn partially white, and that a few pure white hares are seen there annually. There is besides in the Irish hare a tendency to a buff or yellow[1]. In the latest researches on the subject *L. hibernicus* is considered as a species distinct from the Variable Hare[2].

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[1] Of 45 hares seen on 23rd December, 1911, all had the brown spot above the eye and 43 had brown hairs on forefeet.

[2] Giebel, C. G., *Die Säugethiere*, Leipzig, 1859, p. 447.

[3] Thompson, William, *Trans. Roy. Irish Acad.* 1839, xviii., 260.

[4] Beddard, Frank E., *Animal Coloration*, London, 1892, p. 75.

[5] Sir Harry Johnston, *British Mammals*, p. 218, London, 1903.

Of the adult Norwegian hares, as stated, the female never became so white as the male nor did their young one ever become as white as his father. It may therefore be that a young hare does not become so white in its first winter as an adult and indeed this view is held by many who are throughout the year acquainted with these animals in their native haunts. It might be suggested that the female adult was darker than the male on account of sex differences and not age, unfortunately their ages are not known. The main changes took considerably longer in the young hare than in the adults.

The few extracts at the beginning of these notes will indicate the diversity of opinion as to whether the change of coat colour is due to a change of hair, or whether in the case of the autumn change there is a depigmentation of pre-existing hairs with or without the growth of a new crop of hair. The evidence that we have to offer is all in favour of the view that both the vernal and autumn changes are associated with falling off of the old hairs and the appearance of young shorter hairs which are pigmented at the vernal change and white at the autumn change. To the facts already mentioned we would add the following points as regards the spring change. The dark hairs on the nose of the leveret were short, on 22nd March the white ones were long. He looked less plump, presumably from loss of the long white body hair. In the case also of this hare, on 29th April, there was much loose white hair in tufts here and there on body and neck. White hairs came off the animal during the same month in the form of a cloud of fine white hairs and in tufts when he moved rapidly. Dark patches are sometimes obviously composed of shorter hairs than the surrounding white coat, for example on 14th April a dark patch on right side of the adult Norwegian hare was depressed below the white part of coat. In March and April Scottish hare skins short pigmented bristle hairs, not visible on the surface, could be demonstrated by careful separation of the long white winter hairs. With regard to the autumn change the brown hairs remaining on the crown of the Norwegian leveret on 30th November were longer than the adjacent white hair, but the white hair had so increased in length by 4th January as to be actually longer than the old brown hairs on the crown. In two other hares (Nos. 4 and 5, p. 437) long brown hairs were present on the crown at the end of November. Again, in the adult female Norwegian hare on 9th November white areas on face had shorter hairs than the adjoining parts with brown hair; also about the same date (10th November) where the back was grey-white with short fur of uniform length, long dark hedgehog-like hairs, much longer than the hairs of the general short white fur, were present on a darkish part, and projected prominently above the white hairs. There were no long, projecting, white hairs. The dark hairs were scanty and came off in numbers when the hare was handled. Most of the hairs that did come off were brown. About the same time (16th November), when coats were partly white, a bunch of hair gathered on some sticks was composed of brown hedgehog-like hairs. In skins of Scottish October hares short white bristle hairs, obscured by the coloured hairs, were found in quantities after separating the hairs of the dark summer coat; whilst a month later (November) the white hairs, which were now the chief constituents of the coat, were much longer. In a Norwegian hare the white hairs were considerably shorter where there were still long pigmented hairs, than on a part where there were very few brown hairs, that is, the white hairs on the part which become sooner white were the longer. The hairs in the brown crown patch of the same hare showed no signs whatever of bleaching.

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[1] John Guille Millais, *The Mammals of Great Britain and Ireland*, Vol. III., p. 38, London, 1906.

[2] Letter from Mr Oldfield Thomas, dated 29 June, 1911.

That the new coat does not appear simultaneously on all parts is emphasized by a close inspection of the hair. An October skin had white short hidden bristles at flanks, but none on dorsum, a part which is later in changing colour. Other instances are, (1) the different lengths of the white hairs in tufts from the back and buttocks of the Norwegian hare in November, and (2) in the neighbourhood of a brown patch on the body of a Norwegian hare on 28th March no brown hairs could be found amongst the long white hairs, except very close to the patch.

SECTION VII. *Examination of the Coat of* Putorius erminea *at different Seasons of the Year.*

The question of the seasonal variation in the coat of the stoat was studied by MacGillivray[1], who concluded that both summer and winter changes in coat colour were brought about by a renewal of the hair and not by change of colour in existing hairs, unless exceptionally. In referring to the spring change, he says, "This change is not effected by an alteration in the colour of the same hairs, but by the gradual substitution of brown for white hairs," and with regard to the autumn change, "The change from brown to white would seem to take place by the substitution of new white hairs for those of the summer dress." He further says, "I think that this animal sheds its hair gradually, and in small parcels or patches, all the year round." He mentions a March specimen without a single red hair. Later Schwalbe from a study of 15 skins came to the same conclusion as to the change of hair at the autumn and vernal change of coat colour[2].

Bonhote[3] gives a description of the changes in the stoat. He says, "'Poecilomeres' also manifest themselves in some species in a transitory state. The stoat

[1] MacGillivray, W., *Naturalist's Library*, Vol. XIII., pp. 158—9 and 160, Edinburgh, 1843.

[2] Schwalbe, G., *Morphologische Arbeiten*, Jena, 1893.

[3] J. Lewis Bonhote, "The Coloration of Mammals and Birds," *Knowledge and Scientific News*, p. 402, London, 1906.

offers a good example, for when it commences to assume its white winter dress it does so along well defined lines. The first spots to show white are the thighs, whence the white spreads down the hind limbs along the sides, gradually encroaching more and more on the colour of the back. It then appears on the rump and shoulders, spreading down the tail from the former, and down the forelimbs and over the shoulders from the latter. The head remains coloured to the last, but when it begins to change, the lips, nose and ears are the first to whiten, the white from the nose extending up between the eyes as far as the forehead, thus leaving the eyes, post-orbital patch, and frontal patch the last to turn." It is not said whether the observations were made on one animal or on a number of specimens.

Marchal[1] writes: "En Angleterre l'hermine atteint rarement pendant la froide saison la blancheur qu'elle a en Norwège; on a observé, paraît-il, qu'elle conserve souvent sa robe d'été assez avant dans l'hiver; mais, dès que le froid se fait sentir, elle blanchit en quelques jours...le lièvre des Alpes ne revêt pas sa robe blanche à une époque fixe, mais cette époque dépend de la précocité plus ou moins grande de la période hibernale."

An examination was made of the coats of 17 stoats, which had been obtained for the purpose of noting any possible seasonal changes in eye pigmentation.

No.	Sex	Killed or Received	Locality
1	o	January 21, 1911	Kincardineshire
2	♀	February 10, 1909	Aberdeenshire
3	♀	February 11, 1909	Aberdeenshire
4	♀	February 13, 1909	Aberdeenshire
5	♂	February 16, 1909	Aberdeenshire
6	o	February 23, 1909	Aberdeenshire
7	♀	March 10, 1911	Aberdeenshire
8	♂	March 11, 1911	Selkirkshire
9	♂	March 17, 1911	Aberdeenshire
10	♂	March 29, 1911	Morayshire
11	♂	April 3, 1911	Aberdeenshire
12	♀	April 17, 1911	Morayshire
13	o	May 5, 1911	Aberdeenshire
14	♀	July 21, 1909	Roxburghshire
15	♀	August 9, 1909	Aberdeenshire
16	♂	September 2, 1909	Roxburghshire
17	♂	September 7, 1909	Aberdeenshire

Stoats—Nos. 9 and 10—were received alive and uninjured, the intention being to keep them in captivity, but they unaccountably died within a few days.

Stoat No. 1, back, sides, belly, neck, forelegs and feet, hind legs and feet white with yellowish tinge; ears, cheek and under part of muzzle white; ring of brown hairs around eyes, this is continuous with a large brown patch on crown of head which extends backwards between ears for a short distance; dorsum of snout white; whiskers white with some dark hairs; tail white with dark distal portion.

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[1] "La coloration des animaux," *Revue scientifique*, T. xxxvi. p. 17, Paris, 1885.

Stoat No. 2, back, sides, belly, neck, forelegs and feet, hind legs and feet white with yellow tinge; ears white with a few brown hairs on dorsum; face brown with some white on dorsum of snout; brown extends back from crown along spine to level of shoulders, the brown streak becomes narrower posteriorly; whiskers mostly white, some brown hairs; tail yellowish white with dark distal portion.

Stoat No. 3, back, sides, belly, neck, legs and feet white with yellow tinge; ears white, brown at root extending to eye, some brown on upper eyelids and snout; whiskers some hairs brown, others white; tail yellow white with dark distal part.

Stoat No. 4, is white all over tinged with yellow, the only dark parts are end of tail, a few whisker hairs and some brown on upper eyelids.

Stoat No. 5, yellowish white all over, except end of tail which is dark, some brown whisker hairs, and brown hairs on lids, also a few brown hairs extending backwards from lids towards ears.

Stoat No. 6, similar in appearance to Nos. 4 and 5, the only exceptions to the general yellowish white colour of the coat are the dark end of the tail, very few dark whisker hairs, and brown hairs on eyelids and between them and mucous membrane of snout.

Plate ZZ (185) illustrates February coats as in Nos. 3—6.

Stoat No. 7, back has a considerable quantity of brown over spine extending from head quite half way along the back, the brown is most marked anteriorly and shades off posteriorly, posterior third of back, sides and belly lemon yellow; forelegs and hind legs lemon yellow with some short brown hairs on dorsal aspect. The brown hairs are shorter than the white ones and do not pull out readily like the latter; head generally rich chocolate brown, snout dark; ears, convex surface brown, concave surface and free margin white; crown of head and cheeks brown, a few white hairs between eyes; whiskers some white, some dark; tail, proximal part is white and brown, the bristle hairs long and white come out easily, on separating them a brown undergrowth is exposed of fine wavy hairs and of short bristle hairs, distal end dark.

Stoat No. 8, chocolate brown band along spine from head to root of tail, narrowest at level of shoulders; sides and belly lemon yellow; all of the legs yellow white; ears, convex surface brown, concavity and margin white; face and crown brown; whiskers partly white, partly brown; tail yellow white, end of tail dark.

Stoat No. 9, back and sides brown, though the lower parts of sides are still yellowish white same as belly, darkest part is along spine; ears brown, many white hairs on concavity which is mostly white; face and crown of uniform dark brown; throat and flexor aspects of limbs pale yellow; some brown on forelegs on extensor aspects; hind legs lemon yellow with some brown on extensor aspects, but generally appearance of the hind and forelegs is white; whiskers partly white, partly dark; tail, proximal part brown with lemon yellow beneath, distal portion is dark.

Stoat No. 10, back and sides brown, darkest along spine; face and crown brown darker than body; ears brown, a few white hairs in concavity; belly lemon yellow; forelegs and feet lemon yellow with brown at upper extensor aspect of leg; hind legs mostly brown on extensor aspects and yellow white on flexor aspects; whiskers some white and some brown hairs; tail, brown proximal portion with narrow yellowish white band on under surface which extends half way to the dark distal portion.

Stoat No. 11, back and sides brown; belly yellow white; foreleg (right one lost) brown at upper extensor aspect, in other parts mostly white; hind legs, left leg, mottled with brown on yellowish white, is lighter than right leg which is much browner; crown and face brown, head and spine are darkest parts of the coat; ears brown, a few white hairs in concavity; whiskers some dark, some white; tail, distal part dark, proximal part brown, a few pale yellowish hairs on under surface near attachment.

Stoat No. 12, back and sides brown, darkest along spine, belly lemon yellow; forelegs mostly lemon yellow, some brown at upper part of extensor aspects; hind legs brown on extensor aspects, yellow white on flexor aspects; face and crown dark brown; ears brown, some white hairs in concavity; whiskers partly brown, partly white; tail, distal part dark, proximal part brown with yellow band on under part extending from attachment half way to dark distal part.

Stoat No. 13, back and sides rich brown; belly yellowish white. No particulars of rest of coat which showed (from memory) nothing markedly different from an ordinary summer coat.

Stoat No. 14, back and sides brown; belly yellow white; forelegs, extensor aspects brown, flexor aspects whitish, dorsum of feet faint tinge of brown; hind legs mostly brown, lighter on flexor aspects; face, crown and ears brown, face and spine are darkest situations; no white hairs on ears; whiskers have some white hairs; tail, proximal part all brown, no lemon yellow beneath, distal part dark.

Stoat No. 15, back, sides, and face brown, face is darkest part; ears, brown; forefeet brown, lighter on flexor aspects; whiskers chiefly dark, some white hairs; tail, brown proximal part, dark distal portion—(hind legs absent).

Stoat No. 16, this skin has same appearance as last; darkest parts are head and along spine and tip of tail of course; hind legs and feet brown, lighter on flexor aspects; belly nearly white, very little yellow tinge. See Plate ZZ (185).

Stoat No. 17, back and sides brown, belly yellowish, the yellow is very marked in this specimen; forelegs at lower parts and feet chiefly white, also flexor aspects; hind legs brown; face, crown and ears brown; whiskers, both white and dark hairs; tail, brown proximal part with some yellow hairs on under surface which extend from attached end half way to the dark distal end. See Plate ZZ (185).

Any conclusions to be drawn from the appearances presented by these skins as to the sequence of the change of colour or as to whether the hairs are removed, or not, must refer almost exclusively to the spring change, as there are no specimens for October, November and December. Likewise any estimation of the rapidity in change of coat colour would be of little value, for the number of specimens is insufficient. Our whitest skins are the February ones, and skins with summer coat occur from April to September. The five February specimens are all winter coats. Of the four March specimens the two earlier ones are winter coats, the next is only partly a winter coat and the latest, obtained on the 29th, is a summer coat. Both April specimens are summer coats, so it seems that in general terms the summer coat is assumed at end of March or early in April[1]. The winter coats have longer hairs than the summer coats. On following the spring change and beginning with the whitest February skin (No. 4) a gradual increase in colour from the commencement to the completion of the full summer coat can be seen. The head and nape of neck show the first signs. A rich brown appears in these situations (No. 2) and extends in the form of a band further and further down the spine (No. 7) until the tail is reached (No. 8). Some time in March a general change in the back and sides of the body becomes obvious as a brownish tinge amongst the white winter hairs. This is seen as regards the anterior two-thirds of the body coat on 10th March (No. 7). The feet, legs and ears retain the winter appearances for some time after the body coat has assumed its summer colour (Nos. 9, 10 and 11). The under part of the tail remained pale yellow until 17th April (No. 12). Although our material has scarcely any bearing on the winter change it is seen that in a September skin (No. 17) pale yellow hairs are present on under part of proximal portion of tail, and as they were not present in the July and August skins it may be that they are early evidences of a commencing winter coat. In the same skin the feet and legs showed more white than the previous September, August and July skins. The dark hair on the head of the January specimen appears to be part of the previous summer coat, which has not even yet changed. This agrees with Bonhote's statement that the frontal patch is one of the last to turn, and also with what we have seen to occur in the hare. Not even the lightest skins were entirely free from brown hairs. In every specimen there were at least a few brown moustache hairs, and even in the whitest skin (No. 4) some brown hairs on the upper eyelids. A March stoat without a single red hair is mentioned by MacGillivray[2]. As in the hare then there appears to be a main change in the coat in spring-time which is preceded by other changes and succeeded by minor changes which are not completed for a considerable time. The patchiness during the main change is not so marked as in the hare. In the stoat the early vernal changes occur on the head and upper part of spine, whilst in the hare it was on the side of the body. The late changes in both animals are on the legs and ears and in the stoat also on the under part of the tail. The latest change in winter occurs on the head. There is good evidence in this series of skins to show that the summer coat is a growth of new coloured hairs, for in some of the specimens (Nos. 7, 8 and 9) short pigmented hairs can be seen in quantities when the longer white hairs are separated so as to expose them. On the proximal part of the tail of stoat No. 7 which was partly white and partly brown the long white hairs are easily detached and brown hairs exposed beneath. No short white hairs could be found in the two September specimens obtained early in the month.

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[1] A stoat with summer coat, caught inland in Aberdeenshire on 4th November, 1911, has lived in captivity to the present time (15th February, 1912), without showing any sign of change to winter coat. Another stoat caught at same place on 29th January, 1912, has a nearly completely white coat. Their ages are not known. A sportsman resident in the country says that where he lives on the coast he believes that only about a third of the stoats turn white in winter; so it may be that our two April skins and 29th of March skin had never been white. In a letter, 14th February, 1912, the gamekeeper who caught our living stoats says that there are not many that are not white in winter. He occasionally sees one that is brown and he shot one a week ago that was as brown as in summer.

[2] *loc. cit.* ftn. p. 442.

Dr W. Clark Souter kindly prepared the skins of these animals and has given much help with these notes.

The evidence collected in the observations recorded above is distinctly in favour of both a spring and autumn change of coat. We have been unable macroscopically or microscopically to detect any evidence either of the appearance of pigment in the white hairs, or the bleaching of the coloured coat. Explanation therefore of the leucosis must be sought rather in the general metabolism of the body than in any climatological influence on the developed hair itself. The existence of particoloured hairs (see Appendix A) can be accounted for in the same manner; no evidence was at any rate found for the destruction of pigment granules in the non-pigmented segments.

The views held on the subject have been very diverse, and it is of course possible that the leucosis of all winter white animals does not take the same course. It has been asserted that both changes take place by loss or gain of pigment in the hairs; that both changes are due to moults; that the summer change is due to a moult and the winter change to bleaching of the hair; that the changes are due contemporaneously to moults and to pigment changes; and that the bleaching was due either to chemical processes, or to phagocytes or chromophages, which entered the hairs and destroyed the pigment. For those who wish to follow some of the literature on the subject the references below are given—in several cases the observational evidence is of a very slender character.

Literature.

(1) E. SABINE: *Captain Parry's Voyage for the Discovery of a Northwest Passage in the Years* 1819—20, London, 1824, Appendix, Vol. VIII., p. clxxx. Captain Sabine noticed that "banded" hairs in *Lepus glacialis* occur as long solitary hairs: cf. our Appendix A.

(2) JOHN RICHARDSON: *Fauna Boreali-Americana*, p. 218, London, 1829. Considers that summer coat arises from change of hair and winter by bleaching in *Lepus americanus*—"by a lengthening and blanching of summer fur."

(3) JAMES CLARK ROSS: Zoology, Appendix to the Narrative of a Second Voyage in search of a Northwest Passage...during years 1829—33, London, 1833. Gives notes on polar hare, arctic fox and lemming. The latter placed in cabin did not change colour, but removed

to the deck on Feb. 1st, on the next morning after a temperature of 38° below zero, the fur on cheeks and a patch on shoulders had become perfectly white. It was wholly white in a week except a "saddle" from shoulders to middle of back. All white parts of fur were longer than unchanged portion, and the ends of the fur only were white as far as they exceeded in length the dark coloured fur. The polar hare changed although kept in cabin as quickly as those outside. Ross apparently does not believe in change of the coat itself.

(4) F. L. M'Clintock: *Voyage of the "Fox" in Arctic Seas in search of Franklin.* Various notes on winter white animals, without statement as to method of change (pp. 160, 186, 247, 252 and p. 253 for an albino (?) musk ox).

(5) F. H. Welch: "Observations on *Lepus americanus* especially with relation to modifications in the Fur consequent on the Rotation of the Seasons, and the Change of Colour on the Advent of Winter; based on specimens obtained in the province of New Brunswick, North America." *Proc. Zool. Soc. of Lond.*, pp. 228—236, London, 1869. Holds that the winter coat is shed in *Lepus americanus*, but that the summer coat is partly blanched and partly shed.

(6) E. B. Poulton: *The Colours of Animals*, London, 1890, pp. 92—103. Considers that existing dark hairs become white, and holds that air bubbles cause even dark hair to become white in spite of pigment. (Our microscopic examination of white hairs of the winter coats gives no support to this view.)

(7) G. L. Johnson: "Contributions to the Comparative Anatomy of the mammalian Eye, ..." *Phil. Trans.*, Vol. 194, B, p. 19, London, 1901. Notices that the appearance of the eye in the arctic fox remains the same in summer and winter. No microscopic investigation of the eye.

(8) E. A. Wilson: *National Antarctic Expedition* 1901—4. Natural History, Vol. II., Zoology, II., pp. 25—26. Attributes production of pigment to active tissue metabolism, and associates scanty production with gain in animal economy, but does not discuss the method of winter-whitening.

(9) G. E. H. Barrett-Hamilton: *Proc. Royal Irish Academy*, Vol. 24, B, p. 306, Dublin, 1902—4. Says that J. Barcroft in Scotch variable hare kept in the Physiological Laboratory at Cambridge could note no sign of an autumn moult.

(10) *Guide to the British Vertebrates exhibited in the Department of Zoology, British Museum (Natural History).* Published by order of the Trustees, London, 1910, p. 3. Speaks of the *bleaching* process going on in Scotch mountain hares at the approach of winter.

(11) L. Stieda: *Wiener Medicinische Wochenschrift*, March 26, 1910. Discusses the whitening of the hair in man and animals, and denies that the process is in any way one of blanching; it is a change of hair, not a depigmentation of existing hairs. He criticises severely the views of Vauquelin (chemical destruction of pigment) and of Metchnikoff (chromophagic theory) and doubts the validity of all observations recorded on the sudden blanching of human hair.

APPENDIX A. Report on the Microscopical Appearances of Hairs of *Lepus variabilis* at different seasons, by E. Y. THOMSON.

I. *Hair from dead Specimens.*

No.	Date when shot or received	Part of skin taken*	Degree of pigmentation of hairs†	Remarks
1	Jan. 11, 1911	—	Some of the hairs contain no granules. Some of the hairs contain plenty of granules, δ	Three pieces of skin from same hare. Skin placed in 10 p.c. formalin immediately after death‡
2	Jan. 11, 1911	—	Some of the hairs contain no granules. Some of the hairs have bright brown diffused pigment, and in other parts of the same hair are granules	
3	Jan. 11, 1911	—	Some hairs with no granules. Some hairs with very plentiful granules, ϵ	
4	April 15, 1910	Thigh	Some hairs with no granules. Some hairs with plenty of granules and very large, δ. Some with very plentiful granules, ϵ	
5	April 15, 1910	Thigh	Majority of hairs with no granules. Some hairs with plenty, δ; some, very plentiful, ϵ; granules in latter case, very large	
6	April 15, 1910	Dorsum	Some hairs contain yellow diffused pigment and some granules, β. Some hairs with plenty of black fairly large granules, δ. Some hairs with masses of granules, ζ	From foetus found in No. 4 [See Note below, p. 450]
7	May 25, 1909	Upper lid	Some hairs contain no granules. Some hairs with a yellow diffused pigment, and brown granules very plentiful, ϵ	
8	May 25, 1909	Upper lid	Some hairs with a yellow diffused pigment, and a few granules, β. Some with practically none. Some hairs with a decided number of granules, γ	
9	July 31, 1909	—	Diffused and granular pigment in the wavy hairs, large and plentiful granules in the bristle hairs	
10	Aug. 12, 1910	—	No granules. There is no apparent difference between these hairs and the white hairs of Nos. 12, 13, 14, etc.	White specimen
11	Sept. 27, 1909	Under-neck	Most of the hairs with no granules, a few of the hairs with one or two granules, α	
12	Oct. 26, 1909	—	No granules. No diffused pigment	
13	Oct. 26, 1909	—	No granules	
14	Oct. 27, 1909	—	No granules	
15	Nov. 26, 1909	—	No granules	
16	Nov. 26, 1909	—	Majority of hairs with no granules. Some hairs with some granules	
17	Nov. 25, 1910	—	Majority of hairs contain no granules. One or two thick with granules, ζ	Norwegian hare
18	Dec. 30, 1909	—	Quite free from granules in the bristle hairs and the shorter wavy hairs also contain no granules	

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* Skin was always taken from a part that becomes dark in summer.

† The letters α, β, γ, δ, ϵ, ζ are used in the sense defined p. 337 above.

‡ The other pieces of skin were placed in 10 p.c. formalin, but usually several hours after death.

Note to No. 6 in I. above. The mother of the foetus was from Strathdon and her coat when received on April 15, 1910 was described by C. H. Usher as follows:

Coat: Back and sides brown and grey; some areas are greyer, others browner; the greyer parts are at buttocks and lower parts of sides; head and face brown, some grey on upper lip; ears, tip dark; convexity, anterior third brown, posterior two-thirds very light grey, white at a short distance; concavity chiefly white hair; neck brown on dorsum, grey anteriorly; forelegs white with some brown on anterior aspects; hind legs white with some brown at upper part; fud white; belly white. Thus the summer change of coat was in progress. The foetus had plenty of pigment.

II. *Hair Specimens collected from living Hares.*

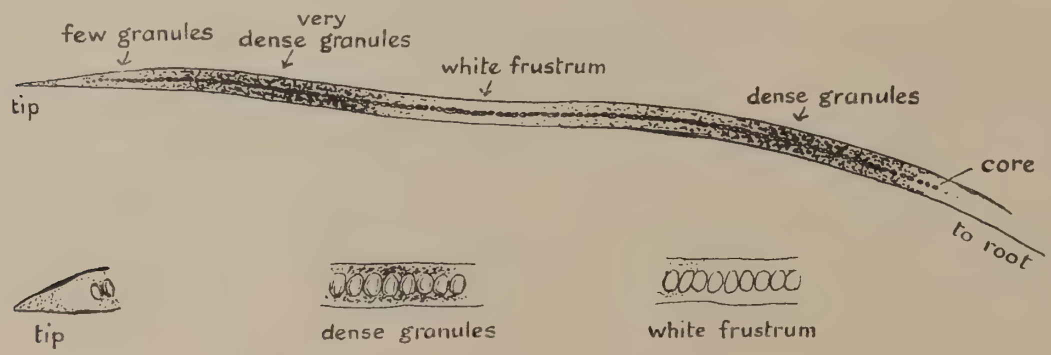
HAIR COMBINGS.

(*a*) *Aberdeenshire, gathered from Heather; L. variabilis; April* 10, '10. Mostly white hairs, but one or two partially dark hairs. The dark hairs are not wholly dark, being quite white about the middle, and then going dark again. In one of these hairs the gradual occurrence and disappearance of granules can be traced. The granules range locally from *none* to *densely packed* (ζ). Cf. Fig. below.

(*b*) *Aberdeenshire, gathered from Heather; L. variabilis; April* 10, '10. Same as above, only contains more dark hairs; but none without a frustrum of white.

Adult Norwegian Hare; L. variabilis, Female; Nov. 10, '10. (See p. 420.)

(*c*) *From Buttock.* Macroscopically: The majority of hairs here are white, but there are a good many black; none of the black hairs, though, are without a white frustrum in some part. Microscopically: Starting from the tip granules are at once seen, and travelling along the hair they get denser, then they get rather fewer, and disappear altogether, and the white frustrum is seen to contain *no* pigment granules. Then still travelling along, granules reappear and become quite dense; they again disappear, and there are no granules for a long way, right up to the root, and near the root the core itself disappears. The white hairs contain *no* granules.



(*d*) *From Back.* Macroscopically: Very much like the hairs from the buttock (*c*), but the dark hairs are in the majority, and the lighter frustra in the dark hairs are pale brown instead of white. Microscopically: The hairs are identical with the ones from the buttock in the way the granules appear and disappear, the only difference being that in the light frustrum, there is a smaller portion with *no* granules, but towards the root they completely disappear as above. In the light frustrum near the tip, the granules are very scattered. White hairs contain *no* granules.

(*e*) *From Side.* Macroscopically: The same as the other two specimens (*c*) and (*d*), only some of the dark hairs have no white frustrum, and these hairs are very dark; but towards the root they become white just as the others. Microscopically: The granules are very densely packed (ζ) in the dark hairs, but these granules disappear near the root. White hairs have *no* granules.

Adult Norwegian Hare; L. variabilis, Male; March 28, '10. (See p. 420.)

Summer part of Coat.

Hairs from Patch. Macroscopically: There are two kinds of hairs, grey hairs and brown hairs.

(*f*) *Grey Hairs.* Examined microscopically. Some granules present (β), but scattered.

(*g*) *Brown Hairs.* Macroscopically: Each of these hairs contains a white frustrum near the tip. Microscopically: Starting from the tip of the hair, granules are at once seen, except at the very tip. Then as one travels along the hair, bright brown granules are seen, becoming more and more in number, until they become *quite plentiful* (δ). Then still travelling along the hair, the granules suddenly thin down and disappear altogether. There is quite a large frustrum containing *no* granules. Then they begin to appear again, and become *quite plentiful* (δ), then gradually they become less, and more and more scattered, and they remain like this down to the root. In all these brown hairs, there are some granules at the root, not *plentiful* (δ), but decidedly *some* (γ).

Same Hare, Winter part of Coat.

(*h*) *White Hairs.* Macroscopically: The hairs are a beautiful white colour. When microscopically examined there were *no* white granules.

(*i*) *Darker Hairs.* The following hairs are from junction of dark patch and white area, and are recognised by their darker colour. The brown hairs when examined microscopically are absolutely identical with the Summer hairs, although one or two of them do not shew a white frustrum.

But the white hairs (which are in an enormous majority) are white and not grey, and are seen to contain a few granules (β), but not distinctly.

Young Norwegian Hare, bred at Aberdeen[1].

(*j*) Macroscopically: There are some dark hairs, some white hairs, some hairs partly dark and partly light. Sample taken from back. Microscopically: The dark hairs contain *plenty* (δ) of granules, the white hairs *none*, whilst the parti-coloured hairs differ in granules from *some* (β) to *very plentiful* (ϵ) in the same hair, and also contain frustra with none.

Aberdeen-bred Norwegian Hare, sent to Surrey, Nov. 13, '10[2].

Specimen of Hair.

(*k*) Macroscopically: Grey, brown and black hairs mixed; the hairs are decidedly coarse. Microscopically: Some hairs have *none*, other hairs have *some* (β) granules, and still others have granules *very plentiful* (ϵ).

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[1] One of the three of first litter.

[2] The after history of this leveret is of some interest. It was sent to E. Nettleship in Surrey, September 2, 1910, then having its summer coat. Subsequently, December 20, 1910, two Scottish variable hares with winter coats were sent. On December 25, 1910, E. Nettleship reported all hares as having their winter coats, but the Aberdeen-bred Norwegian hare as being much whiter; at 20—30 yards, it appeared perfectly pure white all over, although a few weeks previously the face was still a good deal coloured. Early in 1911 a raid was made, probably by poachers, on the enclosure; one hare, the Aberdeen-bred Norwegian, disappeared and one Scottish hare was found next day dead in the enclosure, probably as an after effect of the harrying. The first animal thus disappeared in its winter coat. In February of 1912 a white hare was shot in a wood between a mile and a mile and a half from the enclosure, and E. Nettleship hearing of it, obtained the skin from the shooter. It proved to be *L. variabilis*, and there can be little doubt that it was our original Aberdeen-bred Norwegian hare. The coat was as white as in the previous winter, so that we may conclude that *L. variabilis* even in the south of England and with a mild winter, without snow, will change its coat, and this for two seasons. Of course Hindhead where the hare was kept is 700—800 feet above sea-level and the vegetation three to four weeks behind that of the low country around.

C. H. Usher describes the skin as follows: Face; right side absent, left side white, torn above upper lid, so that presence or absence of "brown tuft" cannot be determined. Crown white (part absent). Ears: convexity, anterior third grey brown, posterior two-thirds white; concavity white; tip black; base of ear white. Body and sides white with exception of a few black hairs disseminated along spine about middle of back. Coat is thick and hairs long. Fud, all white. Legs not present. Upper part of thighs white. Neck white. Length of ear from tip to base of cartilage 4″, length of skin 23″. The fact that this hare has twice changed coat in a fairly mild climate, without even a previous change in a cold district, seems to suggest that the change is not related to environmental but to hereditary conditions.

Aberdeen-bred Norwegian Hare, a few days old. June 8, '10. (See p. 420.)

Specimen of Hair from Back.

(*l*) Macroscopically: Grey, speckled brown and black hairs. Microscopically: Hairs contain granules of all quantities, some *very plentiful* (ϵ), and some *densely packed* (ζ).

Conclusion.

In examining the winter and summer hairs of these animals, no trace of any process of loss or gain of pigment was found; any dark hairs that were seen with the white hairs (winter coat) were exactly the same as the summer dark hairs, and appear to be the remains of the summer coat; there was no sign of any weakening in the pigment nor of any breaking up of granules.

Appendix B. Changes of Coat of Captive Norwegian Hares.

I. *Adult Norwegian Male Hare.*

Date	Back	Right side	Left side	Neck	Fud	Belly	Foreleg	Hind leg	Face	Ear (convexity)	Ear (concavity)
1909 Dec. 9	White with grey over spine	White	White	White	White	White	White	White	White with brown spot above each eye	White and grey	White
1910 Jan. 11	—	—	—	—	—	—	—	—	do. do.	do. do.	do.
Feb. 27	Unchanged	Splash like clotted blood	Unchanged	—	—	—	—	—	—	—	—
Mar. 28	Unchanged	Brown grey patch on flank	Grey brown spot	—	—	—	—	—	R. cheek 2 brown patches, nose brown, brown spots above eyes	—	—
April 8	—	—	Almost quite white	—	—	—	—	—	Darker	—	—
April 14	—	Dark patch larger and depressed below rest of coat	—	—	—	—	—	—	—	—	—
April 20	—	Patch larger, and brown tinge above it	White generally, brown tinge at upper part	—	—	White	White	White	Brown all over	White except black tips and brown roots	
April 24	Brownish, darker patches over spine, some long white hairs	Original brown patch merges into brown of back	Isolated dark grey spots, rest white	—	—	—	—	—	Brown, white on crown and posterior part of left lower jaw, eyelids paler	—	—
May 1	Much darker, especially spine	Darker	Much darker	—	—	—	—	—	—	Darker	Darker
May 4	Much darker	—	—	—	—	—	—	—	—	—	—
May 19	Dark	White stripe remains, otherwise dark	Dark	White	—	—	Upper part getting brown, mostly white, feet white	Feet white	—	—	—
May 27	—	White stripe remains	—	—	—	Greyer	—	—	—	White at ear margins	White at ear margins
May 30	—	do. do.	—	—	White	—	White, getting darker above	White, getting darker above	Eyelids light	White edges	White edges
June 26	—	do. do.	—	—	—	—	Much browner	Much browner	—	White hairs have disappeared	
July 11	Darker than a few weeks ago	Darker; stripe remains	Darker	—	—	—	Brown	—	—	—	—
July 26	—	do. do.	—	—	—	—	—	—	Upper lids nearly white	—	—
Aug. 14	Grey brown	Grey brown, white stripe remains	Grey brown	Grey brown	Brown on dorsum, white beneath, edge grey	Whitish	Brown anteriorly, white posteriorly, feet brown on dorsum	Brown externally, white inner surface, feet mostly white, some brown on dorsum	Brown, lids pale	Posterior dark and bald appearance, dark brown, especially anteriorly	Grey and bald, white posterior margin
Sept. 13	Grey brown	Grey brown with white stripe	Grey brown	Grey brown, lighter, dorsum ruffled	Grey above, white below	—	No change	No change	Brown, lids darker than in August	Brown anterior $\frac{1}{3}$, grey posterior $\frac{2}{3}$	Grey, dark towards posterior edge
Sept. 30	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	No change	No change	No change	No change	No change	No change

Date	Back	Right side	Left side	Neck	Fud	
1909 Dec. 9	Grey	Nearly white	Nearly white	Grey	White	1
Dec. 26	Whiter	Whiter	Whiter	Whiter	——	2
1910 Jan. 11	Light grey	Light grey	Light grey	Light grey	——	3
Feb. 27	No change	No change	No change	No change	——	4
Mar. 28	Grey	Grey. Dark patch seen early in March is larger, site between spine and right shoulder	Grey brown patch on hip	——	White	5
April 8	Broad tract of dark hair over spine, and a few small dark patches	Dark patch larger, hip darker	Dark patch at upper part, dark patch on hip	——	——	6
April 14	Mostly brown	Mostly brown	Mostly brown	Mostly brown	——	7
April 20	Dark	Dark	Dark	Dark	——	8
April 24	Brownish grey with long white hairs, especially anteriorly	Brownish grey with long white hairs	Brownish grey with long white hairs	Shaggy, brownish grey and long white hairs more than on body	——	9
May 1	Unchanged	Unchanged	Unchanged	Unchanged	——	10
May 19	Dark	——	——	——	——	11
May 27	——	——	——	——	——	12
May 30	——	——	——	——	White	13
June 26	——	——	——	——	——	14
July 24	——	——	——	——	——	15
Aug. 14	Grey brown	Grey brown	Grey brown	Grey brown	White beneath, brown upper surface, grey edge	16
Sept. 13	Brown	——	——	Brown	Below white, dorsum grey brown	17
Oct. 8	——	——	——	——	——	18
Oct. 12	Brown, no change	——	——	Brown	Unchanged	19
Oct. 19	——	Grey patch on buttock	——	——	——	20
Oct. 23	Greyer	Greyer	Greyer	——	——	21
Oct. 26	Generally dark, white patch just in front of fud	White patch on buttock larger, buttock greyer	White spot on buttock, buttock greyer, belly—white encroaching on sides	White patch on dorsum, more grey ventrally	White	22
Nov. 2	No lighter	Buttocks lighter	White patch	White patch fused with white of ears, white spots ventrally	——	23
Nov. 5	Distinctly grey (at distance 25–30 yds.)	Grey (at distance)	Grey (at distance)	——	——	24
Nov. 7	——	——	White spot larger	White collar on right side	——	25
Nov. 9	Generally brown	White extending up from belly and white spots near encroaching white edge, buttocks white. Left side piebald		Splotchy ventrally and white ring round it	White	26
Nov. 10	White hair generally, also long dark hairs	White generally	White generally	——	——	27
Nov. 16	Greyer (whiter)	——	——	——	——	28
Nov. 23	Much whiter, brown chiefly on spine	——	——	Dorsum grey, ventrally white	White	29
Nov. 25	——	——	——	——	——	30

	Belly	Foreleg	Hind leg	Face	Ear (convexity)	Ear (concavity)
1	White	White	White	Grey with some brown hairs, yellow brown spot above eyes	Grey	Grey
2	—	—	—	Whiter, darkest about nose	—	—
3	—	—	—	—	—	—
4	—	—	—	No change	—	—
5	White	White	White	Brown from muzzle to level of eyes; brown spot above eye extended, nearly surrounds eyes	Brown ant. $\frac{1}{3}$	—
6	—	—	—	—	—	—
7	—	Mostly white	Mostly white	—	—	—
8	White	White	White	Especially dark	—	—
9	White	White	White	Brown	Mostly brown	Many white hairs
10	White	Feet white	Feet white	Unchanged	—	—
11	—	Feet white	Feet white	Eyelids light, especially upper one	White margins	White margins
12	Greyish white	Brown in front and upper part	—	Lids darker	White edges	White edges
13	—	Mostly white, getting darker above	Mostly white, getting darker above	Lids light	White edges	White edges
14	—	Much browner	Much browner	—	No white hairs	No white hairs
15	—	—	—	Lids yellow-brown	—	—
16	Greyish white	Brown anteriorly, white posteriorly, feet brown on dorsum	Brown externally, white flexor surface, feet white, some brown	Browner than rest of body, lids paler	Brown, especially anteriorly, dark grey and bald posteriorly	Dark grey, posterior margin not white
17	Grey white	Unaltered	Unaltered	Lids darker	Unchanged	Unchanged
18	—	Dirty white with some brown	Snowy whiteness	—	White posterior $\frac{2}{3}$ and at root	
19	White	White except upper part brown	White, externally brown above, feet white, one small brown spot	Brown, lids paler than rest of face, upper lip lighter than last month	Brown anterior $\frac{1}{3}$, white posterior $\frac{2}{3}$	Brown, white patch below tip
20	—	Whiter upper parts	Whiter upper parts	—	Whiter at roots	Whiter; whiter at roots than 19
21	—	—	—	—	—	—
22	—	White, shoulders greyer	White, also feet, thighs greyer externally	Nose, lower part bare appearance, nearly white at nostrils, lids unchanged	White at roots; white post. $\frac{2}{3}$ and ant. $\frac{1}{3}$ (R.) much white	White at roots; whiter than 20
23	—	—	Thighs whiter	Nose whiter	Anterior $\frac{1}{3}$ mostly brown	—
24	—	—	—	—	—	—
25	—	—	R. thigh generally white	White ring round eye, nose whiter	White ring round base	White ring round base
26	—	White	White	Piebald; white ring round nose, connected by white band with white round eye	Generally grey, some brown on anterior $\frac{1}{3}$	—
27	—	—	—	—	—	—
28	—	—	—	White has extended	—	—
29	White	White, no brown on feet	White, grey outer part of thigh	White; nose brownish, crown brown, small brown spot over eyes, lids white	White with brown hair on ant. $\frac{1}{3}$	White, posterior edge grey brown
30	—	—	—	Crown patch diamond-shaped	—	—

Date	Back	Right side	Left side	Neck	Fud	
1910 July 26	Brown	Brown	Brown	Brown	—	1
Sept. 13	—	—	—	—	Brown on dorsum, pale grey beneath	2
Oct. 12	—	—	—	—	—	3
Oct. 19	—	—	—	—	—	4
Oct. 26	Grey brown	Belly—white encroaching on darker sides	Belly—white encroaching on darker sides	—	Grey brown	5
Nov. 2	Dark, buttocks greyer	—	—	Coat scraggy	—	6
Nov. 7	Grey patch at each side of spine, far back	—	—	—	—	7
Nov. 8	—	—	At a distance generally dark	—	—	8
Nov. 9	Brown, but greyer, buttocks greyer than back	Greyer	Greyer	Grey at nape	Grey brown	9
Nov. 16	Rather lighter	—	—	—	—	10
Nov. 23	Greyer, though still brown, buttocks especially grey	Greyer, though still brown	Greyer, though still brown	More grey, especially posteriorly and sides	—	11
Nov. 30	Considerably whiter, buttocks nearly white	Considerably whiter	Considerably whiter	—	—	12
Dec. 7	White or light grey, darker over spine	White or light grey	White or light grey	White or light grey	White	13
Dec. 14	Uniform light grey	Light grey, darker than belly	Light grey, darker than belly	—	—	14
Dec. 21	Light grey	Light grey	Light grey	—	—	15
Dec. 28	—	—	—	—	—	16
1911 Jan. 4	—	—	—	—	—	17
Jan. 11	—	—	—	—	—	18
Jan. 18	White hair, long and more shaggy	White hair, long and more shaggy	White hair, long and more shaggy	White hair, long and more shaggy	—	19
Jan. 25	White hair, long and silky	White hair, long and silky	White hair, long and silky	White hair, long and silky	—	20
Jan. 31	Not perfectly white, no dark patches	Not perfectly white, no dark patches	Not perfectly white, no dark patches	Not perfectly white, no dark patches	—	21
Feb. 8	—	—	—	—	—	22
Feb. 15	—	—	—	—	—	23
Feb. 25	—	Light brown area about shoulder	—	—	—	24
Feb. 28	White hair, very long	Light brown area; white hair, very long	White hair, very long	White hair, very long	—	25
Mar. 6	—	—	—	Pale brown broad band at upper part	—	26
Mar. 15	Light yellow brown streak, 3″ long, in right lumbar region, lies antero-posteriorly	—	—	—	—	27

	Belly	Foreleg	Hind leg	Face	Ear (convexity)	Ear (concavity)
1	Light grey	Brown	Brown	Brown	Brown	Brown
2	—	—	—	Eyelids pale brown	—	Grey brown, dark at posterior edge
3	—	—	—	Upper lip lighter	—	—
4	—	Turning white	Turning white	—	—	—
5	White	White, with brown on anterior part and on foot	White with some brown, thighs brown	No change, some whisker hairs white	Paler	No change
6	—	—	—	Dark	—	—
7	—	—	—	Much whiter	—	—
8	—	Whitish, also feet	White on knee	Small part white at each side of nose	White posterior $\frac{2}{3}$ and root	—
9	—	White	White, brown on feet	Brown, grey brown on sides of nose and eyelids	Grey round base of ears	—
10	—	Some brown on feet	—	—	—	—
11	White	Whiter	Whiter	Cheeks, lids and root of ears whiter	Anterior $\frac{1}{3}$ brown, posterior $\frac{2}{3}$ whitish	Whitish, with brown at posterior edge
12	—	—	—	Brown patch on crown with white above and below it, hair on patch longer than adjacent white hair. White patch anterior to eye	—	—
13	White	White	White	Depression below crown patch seen in profile. Marked crown patch with long brown hair; the adjacent white hair is shorter hair	Grey, anterior $\frac{1}{3}$ brown grey	Grey
14	—	Pale brown on forefeet	—	Whiter; brown crown patch smaller	—	—
15	—	Pale brown on forefeet, slight	—	Distinctly whiter, *e.g.* round eyes; crown patch encroached upon by white at upper part of nose and at root of ears	—	—
16	—	—	—	Whiter all along nose. Crown patch smaller, no depression on nose seen in profile	—	—
17	—	Some light yellow brown on feet	—	Crown brown patch is smaller, white hair below it longer than brown hair on it	—	—
18	—	—	—	Crown patch smaller	—	—
19	—	Scarcely any brown seen on feet	—	Crown patch smaller, has white centre	Some brown hairs	Some brown hairs
20	—	A few light yellow brown hairs on forefeet	—	Crown patch smaller and less brown, white hair on nose below it is longer	—	—
21	—	—	—	No change; small brown patch on crown and a small area of brown at lower end of nose	Some brown	Not much brown
22	—	—	—	Crown brown patch less, white hair below it is now very long	—	—
23	Whiter than back	—	—	White hairs longer, more white above eyes	—	—
24	—	—	—	Still some brown on crown, otherwise white	—	—
25	—	—	—	—	Considerable quantity of coloured hairs	—
26	—	Doubtful whether the light brown hairs on feet have increased	—	Rather less white, nose below crown patch is darker	More brown on anterior $\frac{1}{3}$ doubtful	More brown doubtful
27	—	—	—	—	—	—

Date	Back	Right side	Left side	Neck	Fud	
1911 Mar. 18	Lumbar region, brown streak on right side. Suggestion of brown showing through white hairs	Suggestion of brown showing through the white	Suggestion of brown showing through the white	Brown band broader and extends further back. Small dark patch below right ear	—	1
Mar. 22	Unaltered	Brown patch on shoulder more conspicuous	Faint brown patch on shoulder	Brown round neck more obvious	—	2
Mar. 25	Lumbar streak less conspicuous owing to brown patch below it. At a distance body looks white, but head darker. Brown showing through more strongly, at a distance is quite white	Large pale brown patch immediately below lumbar streak. Brown showing through more strongly	Brown shoulder patch unaltered. Brown showing through more strongly	Upper part brown	Pale grey above, white beneath	3
Mar. 29	—	Distinctly brown	No change	—	—	4
April 1	Mark on right lumbar region very conspicuous, otherwise little change	Little change	Little change	Sandy coloured ring round it	—	5
April 5	Back and sides generally speaking would be called white. Brown tinge a little more evident, animal looks less plump. Dark lumbar streak more marked	Brown patch below lumbar streak. Brown patch on shoulder	Brown patch posteriorly, corresponding to one (below lumbar streak) on other side. Brown patch on shoulder	Light brown broad band round neck	—	6
April 8	Darker, not so dark as sides except over spine. Lumbar streak darker, but no longer	Darker. Shoulder patch not so marked as on left side, hip patch extends short distance down thigh; both patches are light yellow brown, more marked than the brown tinge on body generally	Darker. Light yellow-brown large patch on shoulder, another on hip, both badly defined	Back of neck ragged and grey	—	7
April 9	—	Both patches larger and occupy about half the side	Both patches larger and occupy about half the side	—	—	8
April 12	Lumbar streak unchanged. Two short dark streaks over spine posteriorly	—	—	Neck yellow brown	—	9
April 15	No longer white, considerably more brown. Lumbar streak less marked	No longer white, much darker between shoulder and hip	No longer white, much darker between shoulder and hip	Nape of neck brown	No change	10
April 19	(No notes; photograph only)	—	—	—	—	11
April 22	Generally darker, is neither a winter nor a summer coat. No patches, though differences in shade which merge one into another. Darkest over spine posteriorly	Generally darker, is neither a winter nor a summer coat. No patches	Generally darker, is neither a winter nor a summer coat. No patches	Back of neck not so shaggy	No change	12
April 26	Lighter shade than ordinary summer coat. Darkest over spine	Lighter shade than ordinary summer coat	Lighter shade than ordinary summer coat	—	—	13
April 29	Rather darker than a week ago, still very light, not patchy, much loose white hair in tufts here and there, especially about neck	Still very light, though darker than a week ago, not patchy, much loose white hair in tufts here and there	Still very light, though darker than a week ago, not patchy, much loose white hair in tufts here and there	Darker, though much loose white hair in tufts	Getting dark on dorsum, tip white	14
May 6	Darker	Darker	Darker	Darker	Dorsum has now summer coat	15
May 14	Again darker, a summer coat with considerable quantity of grey at buttocks	Again darker, summer coat	Again darker, summer coat	Summer coat. Two shaggy patches with white hair at upper part	White beneath, summer colour above	16
May 19	Coat darker	Darker	Darker	—	—	17

	Belly	Foreleg	Hind leg	Face	Ear (convexity)	Ear (concavity)
1	—	Unaltered	Unaltered	Browner. Crown patch nearly continuous with brown of nose	—	—
2	—	Feet probably browner	—	Crown patch larger, nose darker, grey brown short hair on it, brown patch below left eye; whiskers, some dark hairs	Grey brown more marked	More grey brown
3	—	White with exception of brown hairs on feet	White	Darker. Brown from crown to tip of nose, upper lip brown and almost uninterrupted brown back to angle of jaw. White ring round eyes	Grey brown anterior $\frac{1}{3}$; posterior $\frac{2}{3}$ whiter	White margin, and generally white with dark patch at margin posteriorly
4	—	—	—	Darker. A few long white hairs at lower margin of crown patch	—	—
5	—	—	—	Some white remaining at base of ears and root of nose, not much	—	—
6	—	Unchanged	Unchanged	Nearly all brown, some white round eyes	—	—
7	—	—	No brown on feet	White ring round eyes extends backwards for short distance	Much white remaining, a quantity of grey amongst the brown, posterior $\frac{2}{3}$ lighter than anterior $\frac{1}{3}$	Much long white hair at edge, grey and brown in concavity
8	—	—	—	—	White at root of ears still conspicuous	—
9	—	—	—	—	—	—
10	—	Unchanged	Unchanged	Darker at base of ears, white patch behind eye continuous with white ring round eye on right side	Darker, grey brown	Darker, grey brown
11	—	—	—	—	—	—
12	—	Nearly quite white	Nearly quite white	Brown round base of ears. Face brown, light part posterior to and around eyes. Whiskers dark	Browner	Darker at part of posterior edge
13	—	Long white hair. Commencement of extension on extensor aspect of dark hair from body	Dark hairs extending from body down extensor aspect of thigh, rest covered with long white hairs	Nose one of darkest parts	Long white hairs at margin anteriorly	Long white hairs at margin posteriorly
14	—	Dark hair much further down extensor aspect, faint isolated brown parts	Dark hair much further down extensor aspect	—	Less white	Less white
15	—	Mostly white, upper part more coloured	Mostly white	—	Still light	Still light
16	White	White flexor parts, brown extends down extensor aspect, pale brown parts lower down and on feet	White flexor parts, white feet, summer coat extending from body down outer aspect	Nose and root of ears very dark, light yellow ring round eyes, whiskers dark, lower hairs white	Anterior $\frac{1}{3}$ summer coat, posterior $\frac{2}{3}$ a quantity of white hair	Quantity of white hair remaining
17	—	More yellow brown on feet	White feet	Face brown, lids darker	Much less white	Much less white

CHAPTER XI.

EXPERIMENTAL BREEDING IN DOGS WITH REFERENCE TO ALBINISM AND PIEBALDISM.

SECTION I.

An Account of some Experiments in breeding Albino Pekinese Spaniels; with a Note on Cases of Nystagmus without Albinism in the same Breed; and Miscellaneous Observations upon some Points in Coat- and Eye-colour in other Canine Breeds and in Horses.

1. *Introductory.* When material was being collected for the present Memoir it became apparent that albinism was seldom met with in the dog except in the partial form of ocular albinism known as "wall eye" or "china eye," the characters of which have been described by Mr Coats and C. H. Usher at pp. 355 and 367 above.

Mr Charles Higgens, Consulting Ophthalmic Surgeon to Guy's Hospital, has told us that he once owned a bull-terrier bitch that was perfectly albinotic and quite deaf[1], and more recently we have heard from Dr Stork, of Bury St Edmunds, a breeder of the Old English sheep dog, that he knows of a living specimen of that breed with cream-coloured coat and albinotic eyes. Another correspondent states that some 25 years ago he bred a pair of albinos from a pair of black and white Japanese spaniels.

Although these three are the only cases of canine albinism that we have authentic information about in other breeds than the Pekinese, we suspect upon general grounds and from the fact that pink noses are usually spoken of as "undesirable" in all breeds[2], that general albinism occurs from time to time in dogs of various kinds but is kept in check by the breeders.

In literature there is little to be found as to albino dogs; references will be given in our chapter on albino mammals. Cornaz (Bibl. No. 326, p. 289 ftn.) writes:

> "Il paraît que le chien est rarement affecté d'albinisme; la plupart des observations citées à ce sujet ont traité des individus qui avaient des yeux vairons, c'est-à-dire à iris blancs, état dont l'analogie avec la leucose est loin d'être démontrée. On parle souvent du loup blanc, toutefois je ne sais si ce dicton a quelque base, et si cet animal a été observé réellement à l'état albin."

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[1] On the liability of white bull-terriers to deafness see p. 473 below (Dr Sidney Turner's information).

[2] In some MS. notes upon the good and bad points of the Pekinese dogs, written in English by Mr Wang Yün, formerly of the Chinese Legation, London, who judged the dogs at the Pekinese Club Show in London in 1905, the "Ti Pi" (Bald nose), translated by Mr Wang Yün as "Red nose," is mentioned as one of the worst "blemishes." These notes were given to E. N. in October, 1911, by Mr George Brown, for whom Mr Wang Yün had written them.

We should anticipate that the albino dog would arise most easily in a breed having red to fawn coats and this is precisely the case with the Pekinese. On this very ground of red coat the appearance of partial and even complete albinos in the wild dog may be expected. The Australian dingo bred in captivity has thrown cream coloured dogs from red parents. A fine specimen of such a partial albino was sent to K. Pearson through the kindness of Mr G. Tyrwhitt Drake. The skin in colour is extremely similar to those of the Pekinese albinos. Samples of the normal red dingo and of a specimen faint cream, streaked with fawn, were also sent to K. Pearson by Dr H. Rischbieth direct from Australia, through the kindness of Mr Minchin, Curator of the Zoological Gardens, Adelaide. In neither case was the albinism anything like perfect. The muzzle and pads contained some pigment but to a lesser extent than in the case of the normal dingo.

In the normal dingo there were found on the back of the coat to be three kinds of hairs: (i) *Black Hairs*, dark diffused pigment, masses of granules (η). (ii) *Red Hairs*, bright red yellow diffused pigment, granules plentiful (δ), but small; some red hairs had black tips, with granules more plentiful at the tip. (iii) *Light Yellow Hairs*, slight pale yellow diffused pigment, *some* granules (β). In the hair of the incomplete albino from Australia there were only: (i) *White Hairs*, perfectly clear, no diffused pigment, no granules; and (ii) *Yellow Hairs*, pale yellow diffused pigment, *some* granules (β). In the incomplete albino from Mr Tyrwhitt Drake there were: (i) *White Hairs*, clear and containing no diffused pigment or granules. (ii) *Reddish Hairs*, all these hairs were half white and half red, the red portion of the hair contains a brownish diffused pigment and a plentiful amount of granules (δ); the white portion contains no diffused pigment and no granules.

It will be seen that the chief differences between the normal dingo and these incompletely albinotic dingos are the absence of the black hairs in the coat and the reduction of pigment either by size of granules or absence in patches in the red or fawn hairs. Mr Coats has provided us with a report on the eyes of these wild dogs: see Appendix B below; it will be seen that the conditions as to skin, hair and eyes are extremely similar in these wild dogs to those which exist in the xanthous negro, reports upon whose characters will be found in Appendix A to this part of our memoir. The macroscopic order of the coats in amount of pigment is: (i) Mr Drake's dingo, (ii) Mr Minchin's semi-albino and (iii) the normal dingo, and this is the order Mr Coats finds for amount of pigment in the eyes of the same animals.

2. *Historical.* The history of our foundation stock runs as follows: In the summer of 1908 Mr Rayner Batten, Surgeon to the Western Ophthalmic Hospital, told E. Nettleship of two albino Pekinese puppies that had been shown to him a few days before by Professor Hobday, the well-known Veterinary Surgeon in Kensington. The puppies, born on 10th November 1907, were brother and sister in a litter of five, the other three being males with "red" coats, dark muzzles and dark eyes. One of these coloured ones had nystagmus and died several months later when about a year old of "gastritis," the remaining two were normal and one of them has become a valuable stud dog. We failed to get into touch with the albinos until E. Nettleship

bought them early in the following November, when they were just a year old. They are Jack and Jill (Pedigree X. 9 and 10: see Plate LVII).

A few weeks later E. Nettleship heard of and secured a third albino, a bitch called Tong, renamed Tong I (Pedigree VII. 17), who was afterwards taken over by K. Pearson.

From the two dams Jill and Tong I and the sire Jack and their offspring, about sixty puppies, all albinos, have been bred under our care, and some crosses between albinos and coloured animals have been made by C. H. Usher, K. Pearson and two lady breeders.

The chart on Plate LVII has been constructed to show, as far as possible, the pedigree of our dogs. A cursory glance shows that no albinism is known earlier than Generation VI., whilst it may at once be stated that no particulars are either known or ascertainable as to any generations earlier than I. and II.

Further inspection of the pedigree shows first that, whilst all the albinos can be traced back either on one parental side or both to the dog Ah Cum (III. 6) and bitch Goodwood Meh (III. 9) and, more remotely, to Mimosa (III. 10), only one of the four parents of Ah Cum and Meh is known, viz. Pekin Peter (II. 4), and next that the albinos are divisible into two principal groups. One group contains the parents and avunculars of Tong I (VII. 17), all of whom are seen to be grandchildren of the above-mentioned pair. The other contains the albinos (XI. 6—18) descended from Jack and Jill (X. 9 and 10), and those (XI. 25—33) descended from Jack and Tong I. It will be seen that Jack and Jill are much further removed from Ah Cum and Meh than Tong I is, being in fact great-great-great-grandchildren of that pair. In both strains or groups there is some mixture of blood that is not traceable to either Ah Cum or Meh.

In general terms the condition approaches nearer to what is generally regarded as perfect albinism in the members of the Tong I group than in the Jack and Jill group, all the albinos with most coat colour having been children of Jack and Jill.

Five single, apparently sporadic, albinos are marked on the pedigree (IX. 12, X. 20, X. 21, XI. 41, and XII. 16 *a*), these are descended on one parental side from the Tong I strain, and the others link up with III. 6 and 9; there is every probability that other albinos, of which no information has been forthcoming, have been born in the same stock during the last few years[1].

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[1] Oct. 13, 1911. The last case, an albino ♂, shown on the Pedigree as XI. 41 is of much interest. His sire is O'lo'peen (Pedigree Chart X. 17) and dam Palace Mi-Mei (X. 20 *a*), a golden sable. Mi-Mei is a daughter of Goodwood Lo (V. 22) and Roma (V. 24 *a* on Chart). Roma is a pale cream bitch with white feet, brown eyes and black nose. Roma was brought from Canton by Mrs Douglas Murray and is now well on in years; she has been mated only with red dogs, never with light-coated ones, and has never had a puppy the colour of herself. Roma appears to be quite unrelated to the albino stock. But the albino above-mentioned is descended on parts of both parental sides from III. 6 and 9, the progenitors of all the others. Roma, however (see V. 24 *a* in description of individual dogs), has a more nearly albinotic coat than her grandson Palace-Yen (see under V. 4) or than Put-Sing, whose coat has been compared with

So far as we have been able to learn there were no Pekinese spaniels in the British Isles and probably none in any part of Europe, in modern times[1], until 1860. Towards the end of that year five specimens were brought to England from the Summer Palace at Pekin after the siege, through the instrumentality of Lord John Hay and Captain (now General) Sir J. H. Dunne[2]. One pair, male and female, were given to the Duchess of Richmond; another male and female belonged to Lord John Hay and subsequently, whilst he was on active service, were kept at Strathfield Saye; the fifth, a female, named Looty, considered by Captain Dunne to be the handsomest of the five, was given by him to Queen Victoria.

Looty was never used for breeding; she was placed in the Royal Kennels and remained there until her death at an advanced age. She was described to us by General Dunne as a very perfectly formed specimen of very small size (a "sleeve dog"), in colour tan and white, the tan predominating. Another correspondent who saw her speaks of her colour as "a rich yellow"; her portrait was painted and an engraving from it appeared in the *Illustrated London News* of 15th June, 1861, and was reproduced in the same paper of 10th June, 1911; the name "Harrison Weir" appears in the corner of the engraving.

The pair belonging to Lord John Hay, which were small, weighing 4½ to 5 pounds each, formed the nucleus of the large kennel of this breed that has been kept up by his Lordship ever since, and although new blood has been introduced more than once there can be no doubt that the numerous specimens still in his possession contain a very large proportion of the blood of the pair brought over in 1860. The male of this original pair, named Schlorff, was "bronze brown" or "black and tan" with black muzzle; the female, Hytien, was black and white. Schlorff lived to be 18. Lord John Hay informs us that for various reasons he was unable to keep records of his stock until 1877, but that since then he has preserved an accurate account; no albino nor any pink-nosed puppy has to the best of his knowledge ever appeared; but once, in 1876, he bred a female with white coat, black nose and dark eyes.

The other pair of the 1860 batch, the male named Guh and the female Meh[3], said to have weighed from 5 to 6 pounds each, were of a golden sable or rich chestnut brown colour with black masks and points; a portrait of them, apparently from an

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that of Goodwood Lo. We are indebted to Lady Binning and Mrs Douglas Murray for the above information.

[1] We do not mean that we have at present absolute proof that the breed never existed in Europe in earlier times. Such previous importation is at least a possibility.

[2] Different opinions are held as to whether these five dogs obtained from the Summer Palace were among the best specimens of the Imperial breed or were, on the other hand, some of the least valuable. On the former hypothesis, which we have heard defended by several high authorities, the Court fled from the Palace so precipitately that even the most favourite and valued pets had to be abandoned. The alternative view is that there was time for selection and that naturally the best were taken, only the poorer specimens being left behind.

[3] Of course not the same as her descendant, Goodwood Meh, Pedigree III. 9, who was not born till 1896.

early, small and poor photograph, is given in the booklet *The Pekingese* (see our p. 476 (8), 1st edition, p. 11 and 2nd edition, p. 14)[1].

We are informed that for a long time, apparently until the early nineties, the descendants of this pair were kept going at Goodwood by direct descent without admixture although written records were not preserved; but in 1896 Lady Algernon Gordon Lennox took the Goodwood Kennel in hand and mated two of the then young bitches, Goodwood Meh (III. 9) and Queenie (III. 4), with the young dog Ah Cum (III. 6) which had been obtained in that year from the Imperial Palace at Pekin by Mrs Douglas Murray. The bitch Mimosa (III. 10) was brought over with Ah Cum and was suspected by some to be his sister, although no one knew for certain the lineage of the pair. She weighed 3 pounds and was of the same colour as Ah Cum. Ah Cum's colour was "red" or "chestnut," and his eyes dark brown; he died in 1906 and is set up as a typical specimen of the breed in the South Kensington Museum; his weight when he arrived in England in 1896, aged about a year, was 5 pounds[2]. Goodwood Meh (III. 9) was mahogany red with black face; she was still living in 1908. No albino ever appeared amongst the Goodwood stock until after the introduction of new blood in Ah Cum and Meh. None of the five dogs of 1860 appear on the Pedigree, for this goes back no further than 1893 or possibly a year or two earlier, 1893 being the year in which Mrs Loftus Allen imported the "grey brindle" dog Pekin Peter (II. 4). Pekin Peter, who was quite young, had been bought in Shanghai, but whether he was or was not obtained from the Palace at Pekin is unknown. He is important for us as the sire of Goodwood Meh. A few years earlier, from 1887 onwards, Mr J. P. Bland, of the Inspectorate General of Customs in Pekin, and Mr George Brown, H.B.M. Consul in China, introduced other fine Pekinese from China, but these do not seem to have any share in the albinism. Since then many other specimens have been imported from time to time.

It may perhaps be thought that too much space has been devoted to the five Pekinese of 1860, since no connexion can be proved between any of them and the origin of the albinism. But even this negative conclusion could not be justified without a careful examination of such data as were obtainable.

A very few words may also be suitably added here as to the earlier history of the Pekinese spaniel. The origin of the breed in China or Eastern Asia has not been and perhaps never can be cleared up since we are told on all hands that pedigrees of these dogs are never recorded in China. According to a belief prevalent amongst those best qualified to form an opinion the Pekinese breed has existed in China for a thousand years, and probably longer. Mr George Brown informs us that the Chinese have a legend that the breed originally came from Thibet, and he adds that he has himself seen Thibetan spaniels in China that might well have been taken for Pekinese. The Japanese Toy spaniel is said to be descended from Pekinese dogs taken from Pekin to Japan about seven hundred years ago, but no written evidence can be quoted[1].

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[1] The statements above made are based upon information given to us, in part personally, in part by letter, by Lord John Hay, General Sir J. H. Dunne, and Lady Algernon Gordon Lennox in 1911. Mr Hubert D. Astley writes to much the same effect in *Country Life* for Oct. 7, 1911 (Vol. xxx. p. 525, No. 770); but the Editor in a detailed note to Mr Astley's Article gives a somewhat different account of the dogs originally brought from the Summer Palace, founded upon letters that appeared in that paper, in 1899 from Mr Oliver H. Jones, and 1900 from Mr H. Townshend.

[2] Judging from his stuffed figure in the Museum we think he must have become considerably heavier later in life.

It is probable, but so far as we have been able to learn has not been proved, that the Pekinese breed was brought from China to Italy by Jesuit Missionaries and that the King Charles and Blenheim toy spaniels were largely if not entirely derived from that importation. If such importation of Pekinese did occur we must conclude that it did not find favour with the rank and fashion of those days and that as a pure breed it died out. Certainly but little study of the numerous Pekinese one now meets, either in the flesh or portrayed from photographs, is needed to show that in some of them of the long-eared strain the arch of the cranium tends to become higher and narrower, and the ear to hang flatter against the head, its fringes being longer and the eyes relatively wider apart, and that the *facies* of such specimens reminds the observer of the King Charles.

It is curious that, if such be the origin of the King Charles and Blenheim breeds, no paintings representing early Italian specimens of undoubted Pekinese are referred to by any authors. Lord John Hay possesses and has been kind enough to show E. Nettleship a large oil painting[2] representing a group of a dozen toy dogs all fairly similar in the high broad head and upturned nose, but none with nose as short as in the modern Pekinese, Japanese, King Charles or Pug. Some are smooth coated others long, but none are maned or feathered. Obviously therefore the dogs in this painting, if they are correctly portrayed, can have had but a distant resemblance to those shown in the antique images in bronze, porcelain, ivory, etc., that are believed to represent the ancient Chinese breed. Lord John Hay's picture bears the signature "Jacopo da Empoli, 1575," and is believed on good authority to be the work of that painter (1554—1640)[3].

Whatever may be the value of this painting as an accurate representation of the toy dogs of the period, it illustrates varieties in length of coat that may still be found in different strains of the Pekinese from the smooth haired Ha-pa Kou, anglicised into Hapa or Happa dog[1] or Chinese Pug, to the most typical "Lion-dog" of the favourite type we know. Although there is reason to think that fashions in the colours changed in the Pekin Palace from time to time, it appears that the colours most approved in China for both smooth and long coated varieties are, or have been, particoloured yellow and white (skewbald) or black and white (piebald); whole yellow, whole black, or whole black with four white feet ("stood in the snow"), are good; "red, fox or wolf colours" not so acceptable; one white leg or foot (called "orphan paw") is a blemish; so is a red (presumably our "pink") nose.

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[1] Mr George Brown has been assured by Japanese gentlemen that there were records of the breed having been acquired from Pekin about 700 years ago, but he had no opportunity of seeing the documents. Oct. 14, 1911.

[2] This picture is reproduced in the Hon. Mrs Neville Lytton's recent *Toy Dogs and their Ancestors* (London, Duckworth & Co., 1911), where also many other reproductions of paintings representing toy dogs are given of dates from about 1500 downwards. None have the short nose of the modern Pekinese, Japanese, King Charles, Blenheim, or Pug.

[3] The derivation or evolution of the high or domed skull and of the short nose seems to require further study, notwithstanding the interesting remarks upon the subject to be found in the Hon. Mrs Neville Lytton's book just referred to. The large high cranium is found with both relatively long as well as very short nose, but we do not remember the coexistence of very short nose with a low and relatively small cranium.

Mr George Brown has referred us to E. H. Parker's *China, Her History, Diplomacy and Commerce from the Earliest Times to the Present Day*, London, 1901. Pp. 46—53 state that there was trade between China and Rome as early as the first century of our era, and give dates of subsequent intercourse between Europe and China down to the fourteenth century. Thus the possibility of exporting dogs from China existed.

In connection with this part of the subject the following dates, taken from Haydn's *Dictionary of Dates*, 20th edition (1892), may be quoted :—420 A.D. Nanking became the Capital. Pekin built about 1267. About 1260 to 1368 the Court and seat of Government were at Pekin, then at Nanking till 1410 when they were again moved to Pekin. 1275 Marco Polo sent missionaries to China. 1534 The Jesuit Order founded by Ignatius Loyola.

Although, as already stated, albinos have appeared only in certain limited parts of the pedigree, Pekinese occasionally appear with cream-coloured or white coat, black nose and dark eyes. Their rarity, unexpected arrival and the attractive contrast of their colouring, cause them to be much sought after, but no one seems as yet to have been able to breed them at will. We believe that most of them are really cream-coloured, but Mr George Brown assures us that pure white does occur and that he has himself bred it. Probably careful selection and inbreeding of white with white or cream would soon yield a fairly stable strain, but hitherto breeders seem to have been obsessed with the fallacious notion that albino × coloured will yield the desired white coat with black nose and eyes. We introduced these cream or white individuals with dark eyes and nose into an earlier draft of the pedigree, but deleted them on finding that we were unable to clear up certain of their relationships. A well-known cream-coloured bitch, Roma, is in the pedigree (V. 24 bis); she is mentioned in the footnote on p. 462; and Pailu, who formerly belonged to Mr Brown, is another.

3. *General Characters of the Albinos.* One of the difficulties that the breeders of coloured or normal Pekinese have is to keep down the size and weight and to keep the nose extremely short, the body and legs short, and the forelegs wide apart and bowed outwards[2]. Many, whose points are otherwise good, are criticised by

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[1] For portrait of a "Happa" dog see references on our p. 476 (8), 2nd Edition, p. 126; also *Toy Dogs and their Ancestors*, by the Hon. Mrs Neville Lytton (1911), p. 14.

[2] The view expressed by Mrs Neville Lytton at pp. 246—247 of her book (*loc. cit.*) that "the true Pekingese should not have bent forelegs" is, we are assured, at variance with native Chinese opinion, and is contrary to the requirements of the Pekinese Club originally drawn up by Mr Brown and we believe still maintained. The idea suggested on Mrs Lytton's part (p. 246) that the bent forelegs were originally caused by the puppies being "too heavy for their legs" and that this acquired character has become transmissible, will meet with but little acceptance.

fastidious breeders, because too large. We have been told more than once that large and small specimens do not represent definite, constant strains of the breed and that the same bitch, whether she be large or small, may have in the same litter some small and some large pups—that the small ones may be as perfect in health and vigour as the large ones and as fertile. And thus as it is obviously safer to breed from the larger mothers breeders are advised not to take puppies from the very small bitches. The normal Pekinese, so far as we have seen and heard, vary in intelligence, temper, courage, and other qualities, and similar remarks apply to the albinotic ones —and except that the albinos are somewhat intolerant of strong light and have poor sight, like human albinos, they do not seem to differ in character so far as our limited experience goes from the normal dogs. They certainly tend to run large and long in leg, body and nose, but so do the coloured ones. And this in the albino may simply mean that the numbers have been too scanty to allow of severe selection as to size. It is only fair to add, however, that we have never seen a very small albino and that one lady who bred a good many of the Tong I group speaks of them as running to a large size[1]. Most of them are very courageous and all that we have seen vivacious, excitable and active. None so far have been deformed from birth or otherwise imperfect, except that a few have had projection of the lower jaw. One female pup (XI. 9) became partly paralyzed in the hind legs when a few weeks old, but she was quite happy and lively till 6 months old when, as she was coming into "heat," we thought it better to destroy her. Some, perhaps all, are decidedly nervous, starting or showing momentary fright at sudden unexpected noises. But whether the coloured ones have "stronger nerves" we do not know. One bitch (X. 20, Spook), the whitest of any we have seen, is extremely excitable and has killed several of her puppies. Another, male (XII. 18), seems to be mentally dull compared to the rest but such inferiorities are certainly not uncommon among some of the normally coloured dogs. Infantile mortality has not been very high among the albinos, indeed lower than in some kennels of the coloured ones we have heard of. They are certainly not more liable to ulceration of the cornea than normal Pekinese dogs, indeed but few[2] except Jack and Jill (X. 9 and 10) have had anything the matter with the eyes, and in their cases the attack of corneal ulceration occurred almost immediately after they came to Nettleship and when we had neither knowledge nor experience in regard to their food and management. We know that in some kennels corneal disease is very frequent and in others almost unknown. The fertility of the albinos is not very great, but we believe the normal coloured Pekinese seldom have large litters.

We have not yet had long enough experience to know the average term of life of the albinos. Hitherto, only two adults have died (Tong I, VII. 17, and Mairi bhan, XI. 26); the former had to be destroyed at the age of six years and a half for internal uterine tumour; she could not have lived much longer; the latter had to be killed owing to sepsis apparently following a miscarriage. The normal Pekinese occasionally live to be eighteen. Mr George Brown has sent us a photograph of a cream-coloured bitch (Pailu), aged 15 years, who is still fairly healthy. Fantails (III. 1) lived to be thirteen. Ah Cum (III. 6) was about ten when he died, Goodwood Lo (V. 22) about fourteen. Others might be quoted as long lived.

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[1] Four of our adult albinos weigh respectively 16, 14, 10 and 10 pounds, and a puppy of ten weeks nearly 4 pounds (see X. 9 and 10, XI. 14 and 17, XII. 17). 18 pounds is the maximum allowed at the shows.

[2] Cyclops had an eye removed owing to inflammation; Wee Ling readily takes cold in the eyes, and requires rather frequent eye-dressings.

The albinos do not see as well as other dogs and show more or less dislike of bright light. Their other senses seem to be perfect, and none of them have been known to be deaf[1]; we have never seen nystagmus in any of the albinos. In spite of the relatively short nose they certainly have a good sense of smell; whether it is as keen as larger nosed hounds one cannot say. One of them, Wee Ling (XI. 31), belonging to K. Pearson, will follow by smell game, hedgehogs, and even sheep, etc., that are far out of sight. Mr Brown writes that he has also been struck by their keen sense of smell. Lord John Hay tells us that at one time, when he had a couple of dozen Pekinese, his children used to organise drag hunts in the park, the pack following like hounds and casting about like hounds when there was a check in the scent.

E. Nettleship's dogs do not seem to scent rabbits on the common or in a copse with the keenness of a terrier. On the other hand they never fail to detect the smell of a strange dog on a man's trousers or a lady's dress, and on going into a new room or amongst new furniture, etc., they test every article methodically by smell. They are obstinate or determined in a high degree and less obedient to call than many dogs; a Pekinese albino will return at once and repeatedly to a couch or other place he has set his mind on and will have to be dispossessed many times before he consents to give it up, and he is apt to pay no heed to call—to appear deaf in fact—when he does not wish to come. Like other dogs they often answer better to whistle than to call. No doubt such traits, both in the albinos and normal specimens, depend often on lack of training; and equally of course great differences exist in such matters, between different individuals of other breeds. The Pekinese are relatively hardy dogs and (speaking for the albinos) some may be turned out of doors and may sleep in an out-door kennel at all times of the year. In this respect they differ from the Japanese toy spaniel, which is, we are told, a very tender breed. In regard to distemper in the albinos we have little to say; only three of our group have had it of whom one died, but this immunity is probably due to their passing a rather secluded life and seldom coming near other dogs.

4. *Characters of the Albinism.* The first point is that not one of the albinotic Pekinese that we have had has possessed a perfectly white coat, and that in the eyes of such as have been microscopically examined some pigment has invariably been found[2]. The skin, hair and internal organs of Tong I (VII. 17), of Mairi bhan, and of Tin lo, have been found by Dr Low of Aberdeen (see p. 405 above, and Appendix D to this Part) to contain no granular pigment. Tong I's coat during life was partly

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[1] Some appear to us defective in judging the direction of a sound, *e.g.* Jack, X. 9.

[2] The eyes of the following have been microscopically examined: VII. 17, XI. 8, 9, 12, 13, 15, 18, 26, 29, XII. 9, 15, 21, 22, XIII. 1—5 and 8—10; and the skin in VII. 17, XI. 13, 15, 18, 29, XII. 9; and in VII. 17, XI. 26, and XII. 15 the internal organs also.

pure white but to a large extent pale cream colour and her eyes contained microscopically much more pigment than the appearances during life led us to expect. The whitest we know of is Spook (X. 20), but even her coat is not strictly white all over. As a general statement the back and more or less of the tail, the ears and muzzle are more or less tinted[1], the hair at the root of the nose and lower lids being often the darkest part, the fringes of the ears coming next. The back and sides and parts of the neck and tail vary from pale cream to decided but pale or yellowish fawn. As a rule, perhaps always, the throat, chest and belly and parts, if not the whole, of the limbs including the nails are pure white. It is difficult, of course, to be sure that the feet and legs are perfectly clean and in regard to the dark colour so often present at the root of the nose (the "spectacle mark") much of it is often adventitious, and K. Pearson finds that in some of his dogs it increases when the animal is more than usually out of doors. Nettleship has found diffused pigment, and what he believes to be granules in the hair of this region in *new-born* puppies (see Description of XII. 8, later). In most normal Pekinese the face is the most pigmented part, and the spectacle region the darkest part of the face. From the skin of one, Fi (XI. 9), aged 7 months, no amount of washing with soap and water has removed this mark. According to our observations no definite spectacle mark appears earlier than about 4 months of age (see individual descriptions later)[2]. The skin and visible mucous membranes, including the nose, are always pink and apparently quite devoid of pigment; irides always very pale blue towards the pupil, palest buff or nearly white towards periphery; the pupils shine red in certain lights—the pupil, however, is less conspicuously red than in the human albino or albino rabbit owing to the presence in all that have been examined microscopically of decided pigmentation of the epithelial layer on back of iris and on ciliary body, and to the greater thickness (or perhaps closer texture) of the iris itself. In some of the young puppies the iris was somewhat translucent, but this was not a marked feature. The refraction in XI. 26 and some of her siblings, and in one or two of the grown dogs, showed only slight hypermetropic astigmatism.

The above remarks on the colour of the coat of the albinos apply to adults or those over six months. In young puppies, of the Jack and Jill strain (as distinguished from the Tong I strain), although the eyes and mucous membranes are as albinotic as in grown dogs, the coat is often more darkly coloured than in the darkest of the adults; it is no uncommon thing for a puppy of this strain to be, for the first few weeks, conspicuously dull brown over the greater part of the body and limbs[1]; the white being distributed much as in the adults so that the animal is quite obviously skewbald if we allow the term where the markings are symmetrical as they are here. Good illustrations of the two types of albino puppies are given on Plate ψ[2]. We have never seen the colour continue so dark as it is at birth; from being, it may be, almost mouse- or cygnet-brown, or brown fawn, it becomes in a few months pale yellowish fawn or cream, as if the dark factor in the colour had disappeared. It might be suggested that the total quantity of pigment in the coat of such a dark coloured young puppy becomes spread over the corresponding area as the animal grows; the change, however, is undoubtedly a change of tint as well as of shade, and is not as if due to mere dilution. As a rule whatever colour is present at, say, six months, is as far as we know permanent. But one case, Patty (XI. 13), born 18th August, 1910, is an exception. For some months she was light brown or fawn over the greater part, contrasting strongly with the pure white in the usual places. About January, 1911, Nettleship mentioned her to K. Pearson as one of the decidedly skewbald specimens, but very soon after that her colour began to change and in a few weeks she had become and has remained whiter than either of her parents (X. 9 and 10), as white in fact as VII. 17. Her parents, Jack and Jill (X. 9 and 10), are moderately cream-coloured on the back, nothing that could be called fawn. We repeat that this is the only case in which we have known a decidedly coloured albino go almost white. Whether the colouration is liable to fluctuate in the same animal at different periods after puppyhood we do not know except in the case of the bitch, Jill (X. 10), who certainly once and her owner thinks twice, has become a definite shade darker on the back while suckling and also during the latter part of pregnancy[3]. One correspondent mentions having seen the pink nose of a Pekinese bitch (not an albino) turn black when near whelping time and remain so for some weeks afterwards, when the black disappeared and the original pink "blemish" returned. The phenomena just mentioned appear to correspond with what is known in man and some other animals. We believe white and gray horses are born dark, and white swans, white geese and ducks are coloured as chicks, and several species of wild birds are darker or duller when young than when adult. Babies are often born with dark hair which turns lighter. Pregnant and suckling women not unfrequently show areas of temporarily increased darkening of the skin, even on the face and neck. Mr Paul B. Fearon tells us of a similar occurrence in a litter of West Highland white terriers, of which variety he is a breeder—the litter of five was born on 29th September, 1910; at one month old all had black noses and pads; at three months one had black nose, two chocolate and two quite pink; at ten months the black nose remained black, the two chocolate noses had become pitch black, one of the pink noses had become black; the other pink, which had been the palest of all, had become a little darker.

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[1] We have not succeeded as a rule in finding any *granular* pigment, only diffused pigment, lipochromes, in the hair of these albinos when *adult*, and this applies to the "spectacle mark" as well. Puppies have once or twice shown something that looked like a few granules, but their interpretation is difficult: see in the third section of this Chapter the accounts of XI. 12, XII. 8, etc.

[2] Pearson has noted that the "spectacle mark" will practically disappear if a bitch be shut up, and return when she is running about in the sun outdoors. If hairs from this region be soaked in alcohol, they colour it red-brown, and microscopically examined are free of granules, showing only what looks like a stain rather than diffused pigment.

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[1] The colour is very much like that of the head and neck of a cygnet.

[2] It requires, however, much more definite proof that dogs like XI. 9, XI. 10 or XIII. 15 could lose their piebaldism with age: see Plates φ, ψ and ω.

[3] She has also become quite decidedly darker whilst suckling her fourth litter born 4th August last. E. N., 27 September 1911

It is convenient to mention here, that although probably a majority of Pekinese spaniels at present met with in this country have coats classed as red or sable, *i.e.* reddish brown of various tints and shades, with black faces and spectacle mark and often a certain amount of black amongst the long hairs of the mane, tail and feathering of the legs, a great variety in the colours and shades and in their distribution occurs when no special breeding for colour is practised. Every shade from whole black to white and from rich red mahogany brown (closely resembling rich bay in the horse) through lighter browns to fawn or yellow, and shades of brindle and "biscuit" and "chinchilla," as well as particoloured white with black or shades of brown, are met with and often the puppies of the same litter will differ widely amongst themselves in colour. Doubtless strains of any one colour, or particolour, could be established, but matings of similar colours are not expected to breed true in the first generation; for example we are told that the black pair, Pekin Prince and Princess (II. 5 and 6), have produced puppies of various colours and shades but none whole black; Pekin Prince, however, had some white on chest and forefeet[1].

In the third section of this Chapter most of the albinos are described in such detail as their cases require, including the microscopical appearances in eyes and skin of such as died and were examined. Many of the normal individuals are also described as far as possible.

5. *Notes relating chiefly to Pigmentation of Coat and Skin in some Coloured and Albinotic animals.* The relation between the colour of the coat at birth and its colour in later life, and the relation in white or nearly all white animals between the colour of the white coat and the colour of the skin, are subjects deserving of more methodical and extensive study than they appear to have yet received, apart from questions of protective resemblance and of possible reversion to some earlier type of colouration in remote ancestors.

The colour of the *hairy coat* is substantially the same at birth as in after life in some cases, quite different in others; thus we are told that black horses are born black, browns of various sorts are born brown, though not exactly of their final colour and they soon change. Everyone knows that in horses and donkeys the clipped coat is different in colour, usually darker and less red or yellow, than the untouched coat. In the human subject the lanugo we believe seldom has the colour the hair will have in later childhood and is often much darker; but one medical informant thinks the lanugo of a red haired child is different from that of others.

As to dogs, mention has already been made of the relatively well-marked pigmentation of the birth-coat in one strain of our albino Pekinese; and one breeder told Nettleship that a ten weeks' old normal brown puppy, with black tips to the hairs, that he was looking at, would very likely turn all red when older. On the other hand, Mr Paul B. Fearon, who breeds West Highland white terriers[2], tells us that he does not remember ever seeing a white dog born dark. Human albinos are almost invariably, if not always, born with white or extremely fair hair[1]. The breed of cream-coloured, wall-eyed, pink-nosed horses kept in our royal stables have in all respects the same colour at birth that they will have in after life; they are not looked upon as perfect albinos, none of them being quite white[2]; they breed remarkably true, being all exactly alike in colour and all other attributes.

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[1] Patty of Braywick (IX. 7), mother of Jack, Jill and their litter-brother Wee Wong (X. 9, 10, 12), was red and white or brindle and white. Jack and Jill both show a fairly definite, although faintly marked, particolouring, as in a more marked degree do some of their puppies; and Wee Wong, although red himself, is reported to often beget particoloured puppies.

[2] Some specimens of this breed are white, others cream-coloured.

We have been told, but cannot vouch for it, that the "Himalayan" rabbit is sometimes dark all over at birth, though the final colour is white with dark terminals —nose, ears, tip of tail and legs.

The Dalmatian hound, white with black spots when grown, is, or ought to be, pure white at birth, the black spots beginning to show at about ten days old. The Yorkshire terrier, silver gray back, tan head and feet when grown, is quite black at birth. Fox terriers that will be tricoloured, black and white, with tan about head and ears, have no tan colour at birth; it comes later.

Colour of Nose of Dogs at Birth and afterwards. Dogs are often born with the nose particoloured, pink and black[3] (or ? pink and brown). If the black spots on the nose are bilaterally symmetrical the nose will gradually, in a year more or less, turn quite black all over; but if the black birth-spots are confined to one side of the nose the other side never turns black (information from Dr Sidney Turner).

Nearly all puppies of the Old English or Bob-tailed sheep-dog breed are, we understand, born with pink noses. At about the third day some "peppering" of colour begins to appear and in about a fortnight the nose ought to be quite black. If the puppy is wall-eyed the nose is likely to remain mottled—"butterfly nose" (Dr Stork).

Permanent pinkness of nose without albinism of eyes appears to be well known in various breeds and is regarded as a fault; *e.g.* it occurs in Samoyedes, white Pomeranians, West Highland white terriers, Pekinese[4], and perhaps others. Though the eyes in such cases are not albinotic the irides are said to be often of light brown or yellowish instead of dark brown. Mr Fearon tells us that pink and chocolate noses and light eyes are not uncommon in West Highland white terriers but he has never seen one with wall eyes, *i.e.* albinotic eyes. Change of nose-colour in white puppies from black at birth to chocolate and pink and finally to black again has been mentioned at p. 470, in a litter of West Highland white terriers. But if a puppy of this breed is born with a pink nose it never becomes dark. The change of colour of nose just described in the ordinary puppies is said to be a peculiarity of this breed.

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[1] Only in a very few cases (see detailed pedigrees Part IV) was the hair stated to have been dark or other than almost white at birth.

[2] We have been told that there is a breed of perfectly snow-white albinotic State horses belonging to the King of Spain, and that several of them were killed by the explosion of the bomb when the King's life was attempted a few years ago. Dr Stork informs us that he once saw a perfectly white albino horse in Chiarini's Circus at Bologna, coat glistening white, skin and nose pink, irides pale blue, pupils pink.

[3] Cilis, Ped. XIII. 21, was born with a particoloured nose, it is now quite black; see also XIII. 26.

[4] One breeder of and dealer in Pekinese estimates that perhaps five per cent. of the puppies of that breed have pink noses and light but not wall eyes. We can recall one very perfect specimen of Pekinese, with in every respect show-points, spoilt by a pink patch on the centre of the nose.

Ordinary Skye terriers are reported to often have light eyes but very seldom pink noses.

Colour of Skin in relation to Colour of Coat. In regard to this point the skin in particoloured dogs is said to be usually pink where the coat is white, grayish blue of shades where the coat is coloured. When the hair is white or cream-coloured all over, the nose black and irides dark, the skin is usually pink, but nearly always some black or brown spots can be found in places if looked for, the hair growing from the pigmented spots being as white as that growing from the unpigmented parts. This is the condition for instance in white Poodles, white Fox terriers and some West Highland white terriers[1], but in most specimens of the last-named breed the skin is quite dark over the whole or greater part of the body, and especially underneath. The converse seems also to occur in some instances; we hear for instance of a prize Skye terrier with black nose and eyes and dark gray coat but the skin "pink," *i.e.* presumably lighter than the hair; and of a Fox terrier white, with dark head and a black patch on body, but the skin of the same or nearly the same pink under the black patch as under the general white coat. In human leucoderma the hairs growing on the white patches are said to be white in some cases, pigmented like the rest in others: see our Chapter V.

C. H. Usher finds that in dried specimens of the skins of winter and summer Blue Hare and Ptarmigan the skin is of the same colour in all, whatever the colour of the hair and feathers; but the point needs investigating in fresh moist skins.

In the Silky Fowl when adult the feathers are as a rule pure white, the subdermal connective tissue (not the epidermis[2]) is deeply pigmented.

Fluctuations and progressive alteration of colour are reported both in coat and nose in a few cases. A Samoyede bitch had ordinarily a pinkish nose, but it became quite black when she was pregnant and suckling; in a West Highland white terrier with very light pink nose this always became pitch black when she was suckling. In some partially albinotic birds (*e.g.* Sparrows) that have at first only a few abnormal white feathers the number of white feathers may increase year by year.

6. *Deafness and white Coat or Deafness and Albinism.* We have already said that none of the albino Pekinese are deaf, but we hear on all hands that deafness often occurs in white Bull and Fox terriers, though we understand that in such deaf individuals the nose need not be pink nor the eyes albinotic. On the other hand deafness is said to be much less frequent in white Samoyedes and white Pomeranians even when the nose is pink. Such differences may perhaps correspond with degrees of albinism (although the above statement about Bull terriers seems inconsistent with such a view), for "white" Samoyedes and Pomeranians often have some yellow or fawn on the ears; our Pekinese are not fully white, and "white" Collies and West

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[1] We believe the same is often true of white horses with dark eyes; but as many horses that look white from a distance are really gray-coated in parts when carefully examined, the observation needs verification.

[2] Bateson, *Mendel's Principles of Heredity*, 1909, p. 181. The author's words are "the intense black pigmentation of the mesoblastic membranes."

Highland terriers are often pale cream colour. But the different incidence of the deafness in these various breeds may have some other meaning; does deafness, for instance, ever appear in *long haired* albino dogs? See Appendix E, to this Part for a Report on a semi-albinotic cat.

7. *Wall-Eye and Coat Colour in Dogs.* One observer of large experience associates wall-eye, whether complete or incomplete, of one eye or both, with an irregular distribution, rather than a deficiency, of the coat pigment. Such irregularity may conceivably be of at least two kinds: (1) irregularly distributed or unsymmetrical patches of pure colour, black and white, or black, white and brown; (2) patches of different colours or shades, each patch consisting of a mixture of the two or three elemental colours, a mixture varying in the proportion, and in the degree of blending, of its constituent hues in different animals and in different parts of the same animal. Whether in dogs the analysis has as yet been carried further, to an examination of the individual hairs forming a "gray" or "blue" patch, and to the colour of different parts of the length of each hair, we do not know[1].

As a matter of experience wall-eye in dogs appears to be rare in individuals showing abruptly marked areas or patches of coat colour disposed with bilateral symmetry, and to be met with principally in the breeds and individuals showing an unsymmetrical disposition of the patches and with some patches composed of mixed colours. Thus wall-eye is common in the Old English or Bob-tailed sheep dog, Dappled Dachshunds, Dappled Dalmatians, Merled (marbled or dappled) Collies and Harlequin Great Danes ("Harlequin" means white with jagged patches of black, blue, gray, or brown). But the condition is not usual in specimens of these breeds with other coat colours. Apparently, however, we may meet with wall-eye when the distribution is symmetrical but the constitution of the patches, or some of them, mixed. Dr Sidney Turner tells us of a Collie bitch named Fly in whom the right iris is entirely "wall" or white, the left three-quarters white, the remaining quarter (a sector) brown. Her coat is black (black and gray mixed), tan and white, the white being, as usual, on face, neck, chest and feet, but the distribution of the coloured as well as of the white areas is as symmetrical as it usually is in Collies of these three colours, although the black and gray are intimately mixed. Through the kindness of Dr Turner we have obtained the following statement of Fly's pedigree; we add the usual notation: Fly's (III. 1) mother (II. 1) was a cross between a black and tan bitch of "Old Welsh" breed (I. 1) and an Old English dog with two blue eyes and bob-tail (I. 2). Fly's father (II. 2) was a cross between a Scotch Collie bitch (I. 3) and an Old English dog (I. 4), presumably not a bob-tail. Fly's mother (II. 1) used always to have two or three bob-tails born in each of her litters, but Fly herself, who has already had six litters, has had only one bob-tail puppy, a bitch born bob-tailed and with one wall-eye, the other being brown.

Dr Stork's experience as a breeder of the Old English or Bob-tail sheep dog shows him that a wall-eyed male of this breed usually has wall-eyed puppies, never dark-eyed ones. Most are born with long tails, the "bob-tail" being the result of docking, but some individuals, usually males, repeatedly beget puppies tailless at birth. This congenital absence of tail is, Dr Stork finds, usually associated with wall-eye and the peculiar shuffling gait that is one of the special characteristics of the breed. He believes that by selection a strain of all tailless puppies could be established in a few generations. It will be noticed that the bob-tails and wall-eyes in the pedigree of the Collie Fly came from a male. More than one breeder of Pekinese has expressed the view that in colour of coat the puppies usually follow the sire; a position that may be true when both parents are normally pigmented but does not hold good, as far as our present experience teaches, when the sire is whole white and the dam black. (See Pedigree XII. 23—30, 33, 38, 43—44, XIII. *a*—*c*.) Here the black, whatever be the sex, appears more largely in the coat of the offspring than the white although the latter is not wholly suppressed.

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[1] In guinea-pigs and doubtless in mice such fuller examinations have, we believe, been made. It has also been done for the hairs of human and Pekinese albinos (see pp. 325–9, 344–5 of this Memoir and the hair examinations of Section III of this Chapter).

8. *Nystagmus.* Mention was made at p. 461 above of a male Pekinese puppy, a litter-brother of Jack and Jill, that suffered from nystagmus. This puppy (X. 13) was seen and the nystagmus verified by Mr Rayner Batten, but the animal died a few months later when about a year old of chronic gastric derangement before we had an opportunity of seeing it. His coat was "red" and the muzzle and eyes quite dark, and Mr Batten informed us there was nothing whatever to suggest albinism. Neither of the albinos nor the other coloured puppy, Wee Wong (X. 12), had then, or had previously shown, the oscillating or "scintillating" eyes.

No progress was made in the matter until we heard that the lady who had owned the now dead "scintillating" puppy (X. 13) had another similarly affected, which E. Nettleship at once went to see. This led before long to the discovery of four more, so that we now know of six nystagmic Pekinese puppies in the present pedigree (X. 13, XI. 3, XI. 19, XII. 1, XII. 2, XII. 16) of whom four have been seen. The oscillation in those examined has been horizontal, very rapid and of very small range and it might therefore sometimes escape observation. There was similar oscillation of head in at least one of the six nystagmists. In at least one of the four Nettleship saw, the owner wrote some months after to say that the eyes had become quite steady[1]. The first case died, as already mentioned, when about a year old, and one of the others (XI. 1) that was ailing when seen at the age of 4 months died soon after. We believe the other four grew up and did well. Not one of them showed the slightest trace of albinism of hair or irides; it will be seen, however, from the pedigree that they can be traced to the pair VIII. 6 and 10, who are related to the pair III. 6 and 9, from whom the albinos spring. The litter X. 9 to 13 is the only place in the pedigree at which the albinism and nystagmus are found side by side, and we do not draw any inference from this coincidence of the two conditions.

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[1] There seem to be resemblances between this nystagmus and "spasmus nutans" of human babies. In the latter condition, which comes on some little time after birth, the movements of the head are generally slower than those of the eyes, and the symptoms are said always to get well. We have been told by Professor Bateson and independently by Dr Sidney Turner that some albino rabbits exhibit a slow rhythmical swinging movement of the head.

A remark by the owner of the first case of nystagmus (X. 13) that that litter was one of the first that the father (IX. 4) sired, led us to make enquiry as to the ages of the parents in each case:

X. 13, ♂: Colour red, dark face and eyes; died at about a year; mother aged about 2½ years and had had several previous litters; father's age not stated, but had sired only one litter before (by a different bitch) and was a young dog.

XI. 1, ♀: Light red, muzzle black, irides dark brown; seen at four months and died soon after; mother a year old and father 18 months and neither had bred before.

XI. 19, ♀: Red tipped with black, some white on breast, chin and toes; irides dark; seen at about 10 weeks; mother's age not ascertained; father about 18 or 20 months.

XII. 1 and 2, ♂ ♂, litter-brothers: both red, mask black, some white on feet; irides dark brown; nystagmus not seen till one month old; seen by Nettleship at 3½ months; similar very rapid shaking of head in one of the pair—the larger one; mother 12 months old; father's age not stated, but he was young, and neither parent had bred before.

XII. 6, data incomplete, ♀: Red, black mask; born May 1910 when her father's father was only 2½ years old, and father, XI. 5, therefore about a year; no information about mother's age or colour, but she is stated to have had one, and only one, litter before.

9. *Sources of Information.* The data for a pedigree so extensive as the one shown in Plate LVII. could not have been either collected or arranged without much help, and our warmest thanks are due to the several ladies and gentlemen interested in the Pekinese breed, whose names are mentioned below, for invaluable assistance of many kinds freely afforded and for replies courteously given both personally and by letter to many tiresome questions. Mrs Loftus Allen, Lady Binning, Mrs Brabazon, Mr George Brown (just returned to England after many years' residence as British Consul in Pekin and other Chinese cities), General Sir J. H. Dunne, Mrs Franklin, Mrs Albert Gray, Admiral of the Fleet Lord John Hay, Lady Algernon Gordon Lennox, Mr and Mrs Douglas Murray, Mr James Rogers, Mrs Benett Stanford. We are also indebted to Mr E. W. Jaquet, Secretary of the Kennel Club, and to Mr Millener of his staff for assistance in tracing the pedigrees of various individual dogs.

Some few facts and statements based on long experience have been collected in regard to coat- and eye-colour in some canine breeds other than Pekinese, and as to albinotic horses. For this information we gratefully acknowledge our indebtedness to Sir Henry Ewart, K.C.B., formerly for many years Crown Equerry, Mr Paul B. Fearon, Dr Stork, and Dr J. Sidney Turner, Chairman of Committee of the Kennel Club. Most of this information has been put into the present chapter because it was too late for incorporation in its proper place in our Memoir.

Information has also been obtained from the following publications, many of which contain portraits of the best known dogs. Some of these portraits that represent members of the pedigree are referred to in Section III. of this chapter under the number of the publication given below.

1. *The New York Herald*, European Edition (Paris), Sunday, August 9, 1903, with Supplement, pp. 1 to 4; an Article of two columns headed "Pekingese Lion Dogs in England; New Types and Peculiarities described by a Famous Fancier, Mr George Brown."
2. *The Illustrated Kennel News*, Vol. IX. No. 1, January 5, 1906; Frontispiece and pp. 7 and 10.
3. *The Pekingese Club*, List of Officers, etc., etc., and portraits of certain dogs, 1907, p. 50.
4. *The Ladies Field*, April 6, 1907, p. 195 and seq.
5. *The Kennel*, October 16, 1908, pp. 20—22, "Toy Spaniels," by the Hon. Mrs Neville Lytton; and pp. 25—26 and 33, "Pekingese."
6. *The Kennel*, New Series, Vol. II. No. 17, February 5, 1909, Special Pekinese Number, pp. 1 to 16.
7. *The Illustrated London News*, June 10, 1911, p. 914.
8. *The Pekingese, a Monograph on the Pekingese Dog: Its History and Points*, etc., edited by Miss L. C. Smythe; published by *The Kennel* (1909) Ltd., 65 and 66, Chancery Lane, London, W.C.; 1st Edition and 2nd Edition; dates of issue not given, probably 1909 and 1910.

10. *Summary of Results as to Albinism.* If we sum up from the standpoint of albinism the results exhibited in the pedigree thus worked out together with those reached in our own experiments with dogs, we may note the following points:

The dog, like the man and many birds and mammals we have examined, has not perfect albinism of the eye. There appears to be perfect albinism of the skin, and of all those internal organs where, in the normal dog, there is melanin pigment (see Dr Low's Reports, p. 405 and Appendix D to this Part). With regard to the coat, no pigment granules have been found in the hairs of the adult dogs, which formed the breeding stud, and any yellow in their coats is merely diffused, probably lipochrome colouration. On the other hand the hairs of normal Pekinese spaniels when of fawn or even of red colour—apart from the black hairs—are also occasionally lacking in granular pigmentation (pp. 344—5). In this way they throw light on the relation of albinism in man to red hair. There is rather doubtful evidence of pigment granules in some of the hairs of puppies from the mating ($RR \times RR$) of albino with albino. There is no doubt at all that the mating of albino with albino can produce a puppy with "some colour" in the coat. The reader will realise this by comparing the coats of XII. 9 and XI. 11 on our Plate ψ. Further the mating of albino with albino may produce a puppy like Fe, XI. 9, which is a very marked and obvious piebald, see Plate ϕ (23). It is difficult to believe that such piebaldism or the lesser piebaldism of Fo, XI. 10, could disappear when the dogs were adult: see Plate ϕ (24 and 26) and compare the accounts of these dogs below. It is a great misfortune that Fe and Fo passed into other hands, Fe was destroyed by an accident and Fo has not, as far as we know, been used to breed from. Clearly the effect of constant selection on the offspring of such incomplete albinos would be of the greatest interest. Without such an attempt being made, it does not seem possible to assert that the mating of albino with albino will always produce albinos; it is certain that it sometimes produces a far less complete albinism.

We have at present on record matings of albino with albino producing 16 litters containing 66 offspring. Of these two, XI. 9 and 10, were recognisable piebalds, and XI. 11 was described at five weeks as having "a coat of a decided and uniform brown." Further XI. 13, 15 and 17 appear, at least as puppies, to have had considerable colour and possibly granules in the coats. All these had the usual incompletely albinotic eyes of the breed.

If we consider the mating of normal with normal ($DD \times DD$) our experiments and pedigree can give no information, because we have no means of deciding when a (DR), appears and if an albino had appeared we should have transferred at once both parents to the (DR) or hybrid class. All we know is that V. 22 and V. 24 must both have been (DR)'s and accordingly III. 6 and III. 9, either both (DR)'s or one a (DR) and the other a (DD). The most reasonable assumption to make is that Ah Cum, III. 6, the sire of both V. 22 and 24 was a (DR). If III. 9 were also a (DR), then we might have anticipated other earlier appearances of albinism. We have no evidence of the existence of albinism before the importation of these dogs into England, and then only at first in Generation V. We gain nothing, however, by asserting that the imported Ah Cum was or was not a (DR). And the category ($DD \times DD$) contributes nothing to our knowledge of theory.

Following the usual Mendelian theory we have next to consider the case of normal mated with normal, when both normals carry latent albinism ($DR \times DR$). We can only test such cases by considering: (i) all those cases of normal mated with normal which have produced at least one albino offspring, and (ii) all those cases where we know from other considerations that although there are no albinos in the litter, the parents because of other litters, or because they are themselves the offspring of an albino, must carry latent albinism. Among the pure Pekinese we have 11 such matings giving rise to 46 offspring, 14 of these were albinos and 32 normal. The Mendelian quarter would be 11·5, a moderate accordance of theory and observation.

But the comparison may slightly over-estimate the albinos, for ($DR \times DR$) would occasionally give no albinos, and such cases, unless either parents had given albinos in other litters, would be liable to be excluded from our category. If we turn to the hybrid—black Pomeranian by albino Pekinese—which we term the Pompek, we are certain that the Pompek is a (DR) and our results are more reliable. At present we have only three such litters of Pompek by Pompek involving nine dogs. Of these, six are black with white shirt fronts, thus resembling with, perhaps, a little more white the first cross; one Sheila, XIII. 31, is a remarkable dog, she is reddish sable and is fully described in Section III. of this chapter; she has a black mask and dark brown eyes; she is in fact a reversion in coat colour to the normal Pekinese type: see Plate ζζ (6), (8); the eighth dog was a slatey brown or "lilac"[1] coloured dog with a white shirt front and albinotic eyes—an incomplete albino: see Plate $\eta\eta$ (3). The ninth dog, killed when a few weeks old, was an albino of the usual type. Sheila is clearly not a (DD) which is a black dog, nor a (DR) which is usually a black dog with a white shirt front, but may be whole chocolate; neither can she be called an albino. No simple Mendelian formula thus suffices to describe these $(DR \times DR)$ results.

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[1] As the term is used for mice; the tint is between Nos. 20 and 21 on the glass mosaic scale of the Biometric Laboratory.

We now turn to the case of albino mated with a normal of non-albinotic stock. We have 16 litters of this mating $(RR \times DD)$ providing 57 dogs, and no single puppy was an albino. At first sight this looks like a confirmation of the truth of the recessive character of albinism. But a little consideration will indicate that it is nothing of the kind; and for this reason, that whenever an albino mated with a normal Pekinese gave an albino in the litter, it has been *assumed* that the normal Pekinese came of albinotic stock and the normal dog has been transferred from category (DD) to category (RD), *i.e.* to that of a hybrid with dominant character. Albinism is so mixed up with all strains of these Pekinese, that we could not assume any strain to be certainly (DD). It follows accordingly that in the whole of these 16 litters there could not possibly be any case of an albino occurring. The only instances where we are fairly certain that there is no albinism in one parental stock are those in which an albino Pekinese has been mated with a pure-bred black Pomeranian. There are 17 offspring from such matings in seven litters. Albinism of the eye has not occurred, but 11 of the dogs have large white patches on chest or belly; four are practically whole black and two are chocolate, with differentiated eyes: see XIII. *d.*, p. 507 below. Thus, as far as albinism of the *coat* goes, they are compounds. This category of matings clearly provides little evidence of any simple Mendelian formula applying.

Next we may take the case of normal mated with a dog containing latent albinism $(DD \times DR)$. Here the Pekinese can tell us nothing for or against Mendelism, for in the case of such a mating producing an albino the normal would have been transferred to the (DR) from the (DD) category. The more certain matings of Pomeranian (DD) with Pompek (DR) are only just under consideration and such matings, with more certain results, cannot yet be discussed[1].

Finally, if we take the case of albino mated with non-albino with latent albinism $(RR \times DR)$, the test is an albino appearing in the case of the Pekinese or one parent being known to be a hybrid of albino and normal $(RR \times DD)$. We have at present only five such litters involving 24 dogs, they give 7 albinotic and 17 non-albinotic dogs. This not only clearly over-states the number of albinos—because cases will arise among the Pekinese in which $(RR) \times (DR)$ would give no albinos and these have been excluded from this category and included in $(RR) \times (DD)$—but further one of these eight albinos has had a coloured coat. This one, XIII. 15, was a "lilac"[1] skewbald with albinotic eyes: see Plate ω (left). The result is a very poor approach to the Mendelian 50 °/o of albinos.

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[1] There is absolutely the same uncertainty in the case of human albinism with regard to the classes $(DD \times DD)$, $(RR \times DD)$, $(DD \times DR)$; they cannot serve to prove or disprove Mendelism; while the classes $(DR \times DR)$ and $(RR \times DR)$ can only be distinguished by the presence of at least one albino and accordingly have to be corrected for those non-included matings in which they would lead to no albinos. Thus the albinos are liable, when no correction is made, to be overstated.

The case is indeed worse, if we confine our attention to ascertained (*DR*)'s mated with (*RR*)'s, *i.e.* to Pompeks mated with albino Pekinese. We have at present bred 15 such dogs. Of these only three are albinos, one, XIII. *i*, Gartchonzie bhan (see Plate ζζ (4)) is an albino of the ordinary type; the second is the lilac skewbald, XIII. 18, already referred to, and the third Mor bhan, XIII. 24 (see Plate ζζ (2)), an albino bitch with an almost reddish dorsal streak. Of the remaining 12 dogs, eight were of the Pompek type, black with more or less white on belly and chest (see Plates ζζ (5), αα, and ζζ (1) for XIII. *h*, XIII. 11—12, XIII. 19—21), one, Sené dhu, XIII. 21, has in addition a white forepaw; two, XIII. 13—14, were black and white, *i.e.* piebalds (see Plates τ, ω, αα), and two, Donnach ruadh and Giorsal ruadh, XIII. 22—23, were golden sable with black masks, a reversion to the normal Pekinese (see Plate ζζ (2) and (7)). No simple formula will fit such results as these, and as for a compound formula, it is always possible with enough "factors" to describe *a posteriori* any results, and it then takes years of breeding to demonstrate their correctness or their falsity. A really serviceable theory should describe *a priori* what will take place, when the ancestry are fully known. It is remarkable that in the present experiments the mating of Pompek × Pompek has given so far no (*DD*)'s which should be wholly black dogs; it has given dogs identical with the usual Pompek type, *i.e.* black dogs with white fronts, which may be assumed possibly to be (*DR*)'s; it has given one reversion to the normal Pekinese in the form of a sable dog and two albinos, one less complete than the usual (*RR*)'s, or Pekinese albinos. On the other hand the mating Pompek with albino has produced Pompeks, *i.e.* black dogs with white fronts, presumably (*DR*)'s; sable dogs, which we fail to classify; albinos, presumably (*RR*); and three piebalds (*i.e.* a skewbald "lilac" albino and two black and white dogs). The appearance of these piebalds is quite paralleled by what we know of hybrids in the case of man. It is clear that we can help ourselves out here with a factor for piebaldism, distinct from the colour factor, but we have difficulty then in explaining the appearance of golden or red sables in the descendants of black and white dogs, we must next introduce a third factor for normal Pekinese colour, and then find it will be needful to have a separate factor for albinotic eyes, if we are to get this associated with a "lilac" skewbald. By the time we have reached this complexity, we can account for most of the dogs that have appeared, and for a good many other types which may or may not turn up eventually. Among the 81 resulting types it would, however, be impossible to test numerically the accuracy of the theory, at any rate by breeding dogs. We might even find it difficult to account for the non-appearance of genuine piebald Pekinese with albinotic eyes,—a type we have not yet met with—unless we supposed albinism of eyes and coat to be "coupled" in the Pekinese, but independent after hybridisation. Considering the innumerable grades of albinism of eyes, coat and skin, the wide variety of shades in the Pekinese, and the various intensities of piebaldism[1], we do not believe that any real knowledge can be gained by a theory which leads to such a multiplicity of factors and even then represents each widely-varying characteristic (*e.g.* the 'albinotic' eye) as a "unit character."

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[1] See footnote p. 478.

Our experimental breeding is still being continued, but these preliminary results indicate that albinism in dogs does not readily demonstrate the applicability of Mendelian theory to albinism, and further emphasises the extraordinary complexity of the group of characteristics, albinism of skin, hair, eyes, and internal organs, which have got to be summed up in a "unit character." In this respect the complexity of albinism in the dog and its association with piebaldism strikingly illustrate what we have already learnt of albinism in man[2].

Section II. On the Heredity of Shape of Head and Muzzle in Pekinese and Pomeranian Crosses.

This section, although apparently having little to do with heredity of albinism, is included here for two reasons: (i) because it seems desirable to publish under one cover all our work on dogs up to the present date (April 1913) and (ii) because there is no reason to suppose that rules of heredity which extend to one character will be any less applicable if applied to a second.

The reader must, however, bear in mind two points: namely, first, that our experiments while already for several years in progress are not nearly completed—our numbers for each type of mating are still very insufficient—and secondly that there has been a very large mortality in some of the litters.

The dog has so many advantages—he has a relatively long life, he is big enough to measure, his different breeds are so diverse in colour and form, he has such marked psychical characters which can readily be appreciated by those who live in contact with him—that one is apt to overlook other difficulties, namely, the space, time and energy required for dog-breeding. If dogs of toy breeds are to be kept healthy, they have to be well-housed, generously fed and carefully groomed, and the experiment becomes a very expensive one. It is needful to draw attention to these points, as the relative smallness of our numbers at present is not unlikely to be criticised. We can only point to the counterbalancing advantage, that much more individual description can be provided and photographs taken of each type. With regard to the puppies that die young, their coats can be preserved, their heads measured, and the indices found. Of course the problem naturally arises as to how far the puppy records can take the place of adult observations and measurements. This problem can only be answered by comparing the puppy records with the adult records in the case of the survivors. We have already seen that in the case of some albino puppies there is far more colour in the coat than is preserved at a later stage. There is, however, no doubt about the classification into albino and non-albino, although there is some doubt as to the degree of incompleteness of the albinism. On the other hand, no one can mistake the difference between a chocolate and a black coat even a few hours only after birth. What we have termed in the previous section the "usual Pompek type, black or black with a white shirt front" is also readily differentiated. But "rusty blacks" occur, and brindles with an excess of black hair. Thus the litter, XIII. 19—24, was recorded on the day after birth as consisting of "one black with little white, one black with white markings, one rusty black with white markings, two brindles black and dark red, one albino." It was not suspected that the two brindles would develop into relatively light coloured dogs, *i.e.* golden red sables of the normal Pekinese type. The rusty black developed into a black dog with white markings although in certain lights tinges of red may still be seen. It was, however, possible to make an error between the "rusty black" and the "brindle" puppy, when there was no anticipation of the reversion to the normal Pekinese, which has appeared both in the Pompek × Pompek and the Pompek × Dondo[1] matings. Thus Sheila, XIII. 31, was originally described two days after birth as "black with obvious red tinge." She has developed into a wolf-sable: see Photographs, Plate ζζ (6) and (8). It becomes therefore of great importance to distinguish in the case of the very young puppy between the "rusty black," which will become almost pure black, and the "brindle" which will give a coat like the normal Pekinese. The skins of XIII. 25—30 have been preserved and we believe that they are properly classified as black with white markings (Pompek type), that is to say that they are "rusty black" and not the "brindle" type. The only doubt that can be raised would be about XIII. 26 (see microscopic description of hairs, p. 512), but the macroscopic appearance of coat is more that of the "rusty black" than the "brindle." On the whole a classification of coat at birth, while far inferior to classification at 6 to 12 months, will with care serve many purposes[2].

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[1] For example, if the extent of coloured area in the skin of a piebald be measured, the records of Weldon's mice breeding experiments show that each individual grade of piebaldism is inherited.

[2] It is even conceivable that the appearance in the same stocks of xanthous negroes in association with albinos and piebalds may not be unrelated to the occurrence we have noted above of yellow-red sable dogs.

The next point is how far measurements taken of the heads of puppies at birth or at a few weeks old can be trusted to represent the adult characters. Of course absolute measurements would be of no service, and on this account we have used indices, hoping thus to get rid to some extent of the growth factor. We started by taking a merely verbal record of the appearance of the head of the dogs, and the result of this was that we concluded that the Pekinese muzzle was a dominant character. It was only when considerable numbers of the hybrids had been born that we began to recognise the variety in head-shapes and that the use of vague categories like long and short muzzle were idle. The callipers soon showed that the observer merely recorded as a short or Pekinese muzzle anything that fell sensibly short of the customary long muzzle, and that our hybrid Pompeks were in fact intermediates.

We chose the black Pomeranian to cross with the Pekinese albino, partly because the coats were so entirely different, and partly because the heads were so characteristically differentiated. There is also a marked diversity in the psychical characters of the two breeds. The Pekinese is a royal dog with lordly habits; he is fearless, self-willed, keen on scent, very intelligent and of cleanly habits. The Pomeranian compared with him suggests a cockney upstart, he snarls rather than barks, and is almost invariably a coward of doubtful habits. He will admit defeat at the claws of a cat and consent to share a hearthrug with her, while even a Dondo will put to flight a collie dog who behaves disrespectfully. The Pomeranian characters come out in the hybrids in a marked manner. The Dondo has the pluck of the Pekinese, if something of the nervousness of the albino, but the Pompek and Pompek hybrids are rather cowardly and apt to cringe, and have something of the sharp irritating bark of the Pomeranian. It is not our present purpose to discuss these psychical characters, but their diversity is as great as that of the physical characters and serves to justify the particular choice of Dondo and Pomeranian for hybridisation experiments.

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[1] The term *Dondo* is used here and often throughout this paper for the longer "Pekinese albino."

[2] It would not be wise at present to make any dogmatic statement, but it would seem probable that dogs ultimately black coated (*e.g.* typical Pompeks) look lighter as new-born puppies, and dogs ultimately light (the albinos and sables) look darker soon after birth than they do as adults.

With regard to the head measurements the following have been taken:

(i) From the occipital protuberance to the line joining the mid-points of the nostrils. This we have termed total *head length.*

(ii) From the nasion to the same line joining the mid-points of the nostrils; the nasion is taken as the point on the sagittal plane, where it is met by the line joining the most proximate points of the orbits. An examination of dog skulls shows that the nasion is very nearly on the line joining the closest points of the orbits. This measurement we term *nose length.*

(iii) The maximum breadth of the head in the case of the dog is found on the zygomatic arches, and we term this the *breadth of the head.*

These measures are fairly straightforward, if somewhat difficult to make on a lively dog or one of much temper. But the next is more difficult to be certain of.

(iv) The breadth of the muzzle is measured just under the eyes where the head begins to swell out. It is taken as nearly as possible from the surface of the face in the mid-plane of one carnassial tooth, or 4th premolar, to that of the other.

From these four measurements three indices are formed termed respectively:

The Head Index = Breadth of Head/Length of Head.
The Nose Index = Length of Nose/Length of Head.
The Muzzle Index = Length of Nose/Breadth of Muzzle.

The heredity of these indices is the problem we have had under consideration.

Of course it may be asserted that these indices are very complex characters, and may be compounded of many Mendelian units. To this we must reply that albinism is of a precisely similar character, there is a very large series of characters involved in the pigmentation of different parts of the eye, the skin, the hair and the internal organs, and complete albinism of the one does not involve that of the others. Length of coat is very much of the same character, for there is an immense variety of lengths of hair on head, back, tail and legs, which vary from breed to breed. In our Pekinese the colour of the coat is of a similar character, hairs of widely different tints are found on the same dog, not only in different parts but often in the same parts, and occasionally different parts of the same hair are quite differently pigmented. If it be justifiable to use "Jewishness" and "Gentileness" of face as contrasted Mendelian units, one recessive to the other—notwithstanding the innumerable factors which combine to give facial expression,—we are, we hold, justified in investigating whether our relatively simple indices do or do not "mendelise."

We have already drawn attention to the obvious difference between the Pekinese and the Pomeranian head-shape, reduced to numbers we have for the means[1] of the dogs measured:

	Head Index	Muzzle Index	Nose Index
Dondo	83	48	27
Pomeranian	68	108	39

Further, not only are the means so markedly different, but the total ranges in each index of the dogs we have bred from never even approximately overlap, as the diagrams below will indicate.

The question of the permanence of these indices during growth is an important one, but one not very easy of settlement; this arises from the fact that the errors of measurement are very considerable and seem to be of the same order as the changes due to growth. With an old dog who is accustomed to being handled an index can be repeated to within one or two points on remeasurement, but with a young puppy a difference of four or five points may be made. If puppies be remeasured after an interval of three months changes of four or five points may be found, but as for the same index these points will be up for one individual and down for another, it seems as reasonable to attribute them to the difficulties of measurement, as to growth changes. Of course the same difficulties do not arise in the case of a dead puppy, and might very possibly be obviated by the use of an anaesthetic or by strapping the dog down, but, apart from the risk, such treatment is unnecessary. With the great differences involved in the indices of Pekinese and Pomeranian, errors of measurement of the order referred to will not transfer a dog from one category of head-shape to a second, and this is the vital point.

We will now consider the indices of the various types of hybrids we have bred.

We take first the Head Index for the cross Dondo (or Albino Pekinese) × Black Pomeranian. Diagram I shows the results.

Generation H_0 gives the mean value of the index for Dondo and Pomeranian. Generation H_1—the first generation of hybrids—gives the indices of the eleven Pompeks which have so far been measured. Generation H_2 gives the result of mating the Pompeks among themselves. Below these results, the ranges of Dondos, Pompeks and Pomeranians are given.

If we look at the values of the indices for Pompeks, we seek in vain for any sign of dominance of the Pekinese or Pomeranian head. One or possibly two

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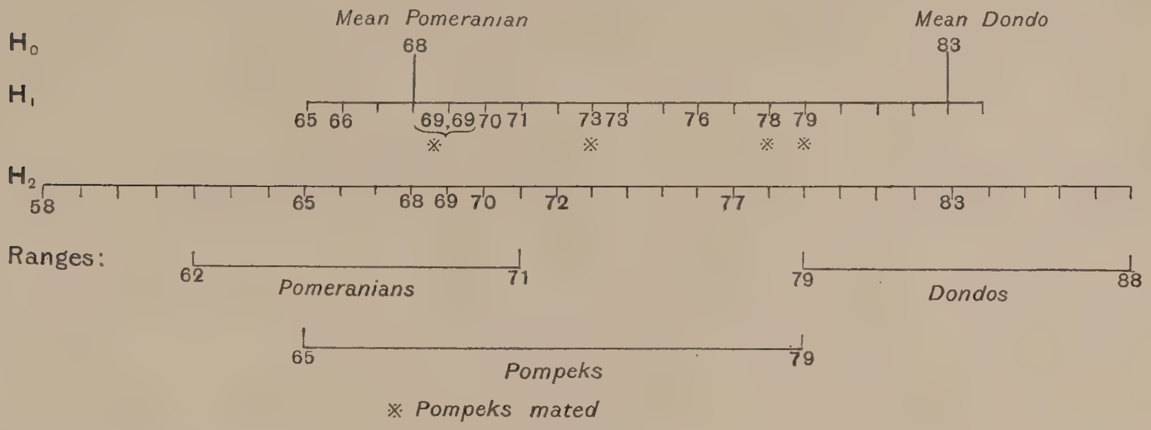
[1] Results in all cases based on eight to nine dogs, and not simply those bred from. The attempt is to determine the *type*; the variations are from the Mendelian standpoint only "fluctuations" of no importance for heredity. It is needless to say that this is not necessarily accepted by us.

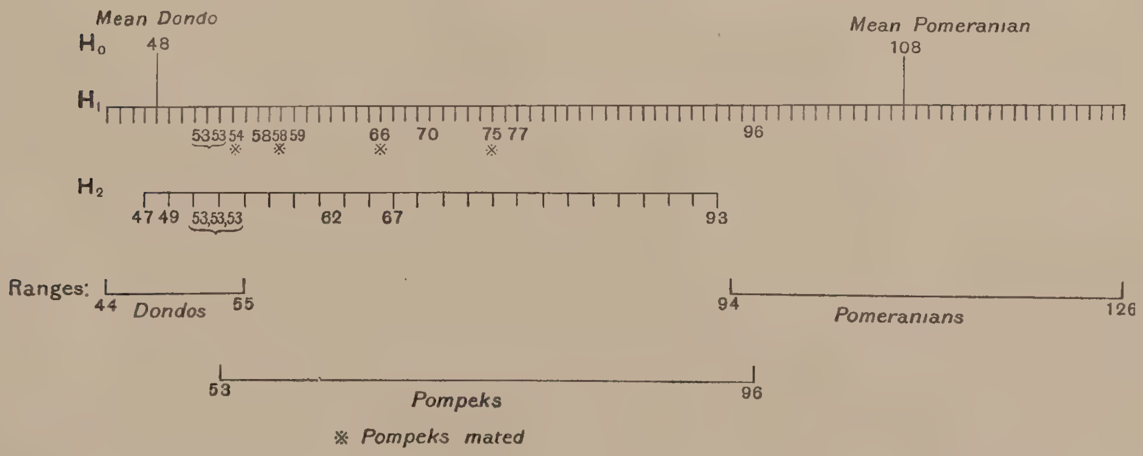
Pompeks might be considered to have Pekinese heads, six might be considered to have Pomeranian heads and the remainder are intermediate. We find no evidence of dominance, and might even assert segregation in the first generation. In the second generation of hybrids, we find one dog well within the Pekinese range; one dog actually below the range of our Pomeranians, and of the remainder four within the Pomeranian range and two intermediates. As the Pompek range largely covers the Pomeranian range, it would be perfectly easy by arbitrary dichotomic lines to get Mendelian quarters and assert segregation, but such lines would equally divide the H_1 generation into three classes corresponding to Dondos, Pomeranians and hybrids, and must lead to the assertion of segregation in that generation also.

Diagram I. Head Indices, Dondo × Pomeranian.



We now pass to the Muzzle Index and inquire whether there is any better evidence here of the chief Mendelian rules of dominance and segregation. Diagram II. represents the data in the same manner as we have given them for the Head Index.

Diagram II. Muzzle Indices, Dondo × Pomeranian.

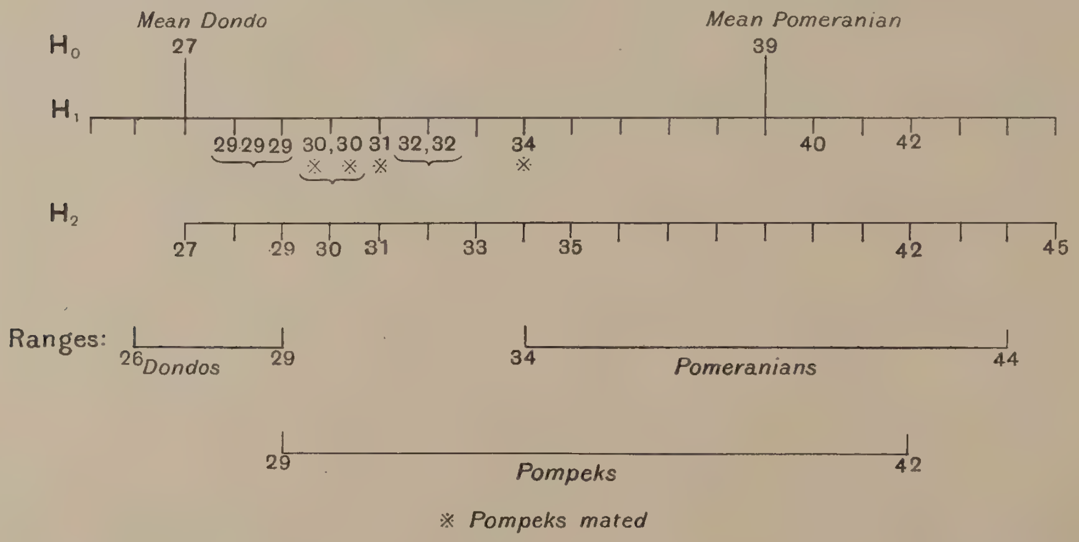


In the first line H_0 we have the mean or type values of Dondo and Pomeranian muzzle indices. In the first hybrid generation H_1, for the Pompeks, we find one index in the Pomeranian range, three indices in the Pekinese range, and seven intermediates. It is extremely unlikely that the bulk of them could ever occur with pure-bred Pekinese. They are in fact intermediate[1] between the Dondo and Pomeranian ranges, but numerically nearer to the Dondo than to the Pomeranian values. Here is the only basis for the conclusion we originally reached that the Pekinese muzzle was dominant. Are we to assert "dominance" of Dondo or Pomeranian? Or has there not been "segregation" in the first hybrid generation? Actually muzzles with indices 60 to 80 are as unlikely to occur with a pure-bred Pekinese as with a pure-bred Pomeranian. They are really a blend of two different types. If we pass to the third line, the H_2 generation, which gives the offspring of Pompek mated with Pompek, we find the whole series with two exceptions lies within the range of the Pompek indices. These two exceptions have muzzle indices of 47 and 49 and fall well in the Dondo range. Actually five dogs fall in the Dondo range, but if we assert that these are examples of segregation, then we are bound to consider that at least three instances of segregation occurred in the H_1 generation.

There are no clearly obvious dividing lines across the offspring of this generation, and we may feel pretty confident that as our breeding continues the gaps in the index series will be filled in. There is certainly no definite evidence of "mendelising" in the muzzle, either by way of dominance or of segregation.

Diagram III represents our results for the Nose Index. In the H_1 generation we have already three dogs within the Dondo nose index range and three dogs within that of the Pomeranians. When Pompek is crossed with Pompek, we find two dogs within the Dondo and three within or nearly within the Pomeranian range. If this be held as evidence of segregation in the H_2 generation, it is equally evidence of there being segregation in the first generation, H_1, of the hybrids. As a

Diagram III. Nose Indices. Dondo × Pomeranian.



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[1] It is a common error to suppose that when a character 'blends' in the offspring, it must lie *midway* between the two parental values.

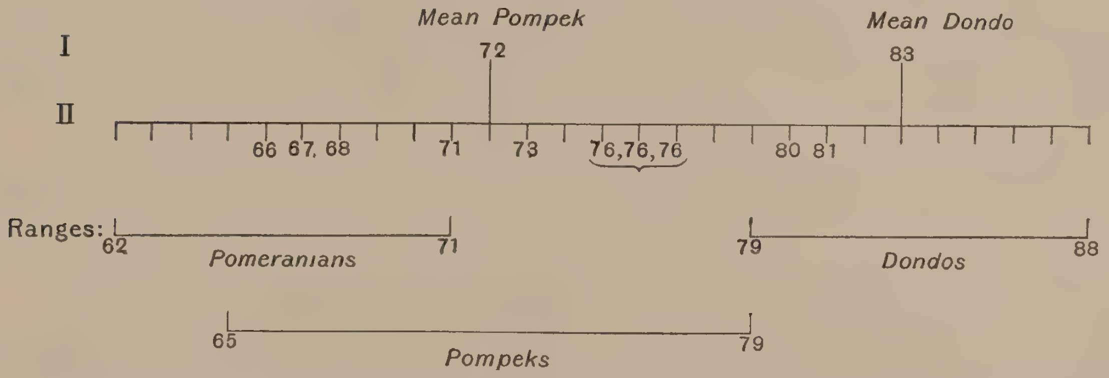
matter of fact, there is in all three index distributions slightly greater variation in the H_2 than in the H_1 generation, but in both generations there are individuals lying within the index ranges of the original races, and Mendelism means more than greater variability, it means obvious dominance in the first generation—which here fails—and the breaking up of this dominance in the second generation in definite numerical proportions, *e.g.* 25 $^\circ/_\circ$ of H_2 should fall into the range of the recessives and 75 $^\circ/_\circ$ into the range of dominants, whichever they may be. It is impossible to assert of any one of the three indices that they break up into 25 $^\circ/_\circ$ (or 75 $^\circ/_\circ$) with Pomeranian and 75 $^\circ/_\circ$ (or 25 $^\circ/_\circ$) with Dondo indices.

We now turn to the mating of Dondo with Pompek. In this case the Mendelian formulae

$$(RR) \times (DR) = 50\ ^\circ/_\circ\,(RR) + 50\ ^\circ/_\circ\,(DR)$$
$$(DD) \times (DR) = 50\ ^\circ/_\circ\,(DD) + 50\ ^\circ/_\circ\,(DR)$$

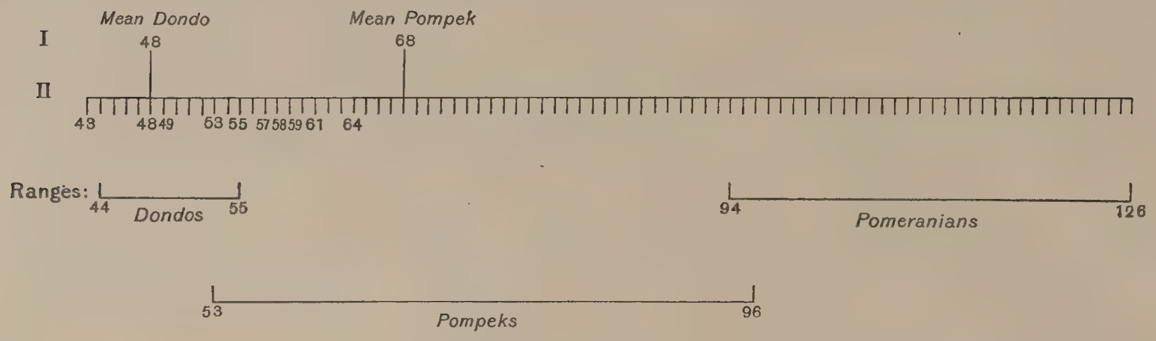
show us that if the Dondo character be recessive and the Pomeranian dominant half the offspring should be of Dondo type and half of Pomeranian type. But if the Dondo character be dominant all the offspring should be of Dondo type, although 50 $^\circ/_\circ$ of them carry latent Pomeranian characters.

Diagram IV. Head Indices. Pompek × Dondo.



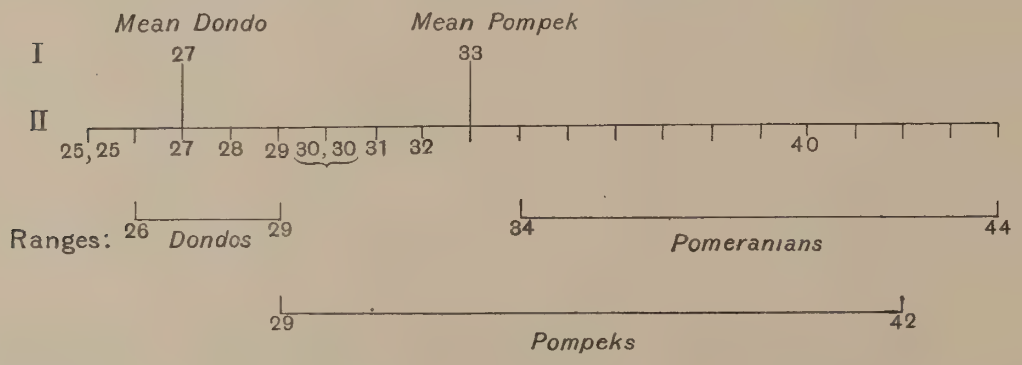
In the first line, I, the values of the indices for the type Dondo and type Pompek are given; in the second line, II, the actual indices of the offspring and below the observed range of indices in Dondo, Pomeranian and Pompek are recorded. It will be seen that we have only two indices that fall into the Dondo range, although there are one or two which are fairly close to it. There are four which fall into the Pomeranian range and four intermediates. It seems impossible to interpret these facts from either standpoint, *i.e.* that 50 $^\circ/_\circ$ have Dondo character and 50 $^\circ/_\circ$ Pomeranian, or that all are Dondo. Almost the same remarks apply to the muzzle indices given in Diagram V. Here not a single index falls into the Pomeranian range. Hence the Dondo muzzle index must be dominant and 100 $^\circ/_\circ$ of the indices ought to fall into the Dondo range. As a matter of fact four do, one is below it and the rest above it. If we assert that the Dondo muzzle is recessive, so as to get here 50 $^\circ/_\circ$, then this statement is inconsistent with Diagram II, where the Dondo muzzle does not behave as a recessive.

Diagram V. Muzzle Indices. Pompek × Dondo.



Lastly in Diagram VI, we have the corresponding data for the Nose Indices. Here again it is impossible to assert either that 50 $^{\circ}/_{\circ}$ are Dondo and 50 $^{\circ}/_{\circ}$ Pomeranian in character, or that 100 $^{\circ}/_{\circ}$ are Dondo. The offspring show only one dog that might, as far as the nose index is concerned, pass for a Pomeranian; three lie actually within the Pekinese range, but two below and some closely adjacent above it, with the rest as intermediates. Nor do we materially better matters if we reject

Diagram VI. Nose Indices. Pompek × Dondo.



half Mendelism, by asserting that dominance is not of importance or is imperfect. For in this case 50 $^{\circ}/_{\circ}$ should show the Dondo character and 50 $^{\circ}/_{\circ}$ the Pompek character. An examination of the diagrams shows how meaningless this is, for actually not only does the Pompek overlap the Pomeranian range in all three characters, but in all three indices the Pompek range either reaches or overlaps the Dondo range. There are thus no definite dividing lines which tell us what is to be accounted a Dondo, what a Pompek and what a Pomeranian head. A loose or merely verbal classification could easily produce a Mendelian 25 $^{\circ}/_{\circ}$ or 50 $^{\circ}/_{\circ}$ out of any one alone of these six diagrams.

There is small doubt, however, that when our number of hybrids is much increased we shall find both for the H_1 and H_2 generations continuous distributions of indices and quite possibly as much "segregation" in H_1 as in H_2. We shall then be in a position to investigate whether the Law of Ancestral Heredity will apply to these obviously blending characters. Meanwhile it is not without interest to examine how far the theory of the "mid-parent" applies to the average results reached. We have not enough data to calculate standard-deviations and get "equivalent males" for our females, so that we have simply taken the mid-parent as half-way between the actual parents. This is by no means the most desirable method as there are probable sexual differences, but they are not so great as we had anticipated. Thus for Pekinese we have:

	Head Index	Muzzle Index	Nose Index
Male	82	48	27
Female	84	48	27

The male Head Index is pulled down below the female by two dogs whose head breadths are remarkably small compared to those of other dogs.

Taking the mid-parent of Dondo and Pomeranian we have:

	Head Index	Muzzle Index	Nose Index
Mean Dondo	83	48	27
Mean Pomeranian	68	108	39
Mean Mid-parent	75	79	33
Mean Pompek	72	65	33

It will be seen at once that with the exception of the muzzle index, the mean Pompek agrees closely with the mid-parent; and in the case of the muzzle index the Pompek value is an intermediate, if not a mid value.

If we suppose any theory of dominance such values would be impossible.

Next consider the result of the cross Pompek × Pompek:

	Head Index	Muzzle Index	Nose Index
Mean actual Pompek	72	65	33
Mean Pompek × Pompek	70	60	34

It is clear that there is no change in mean values for these indices when the hybrids are crossed together. This of course does not prove that the variability is not greater, but it does demonstrate that the average head characters are not changed from the first to the second hybrid generation, a result which seems quite inconsistent with any theory of dominance, but would not necessarily be inconsistent with segregation, if the hybrids H_1 had a blended character.

We next turn to the Pompek × Dondo crosses and find:

Mean Mid-parent	Head Index	Muzzle Index	Nose Index
Calculated: Pompek × Dondo	78	56	30
Observed: Pompek × Dondo	74	55	30

There is an extraordinary agreement here and we see the offspring approaching the original Dondo head type, as three instead of two of the grandparents are Dondos. It is difficult to square these results with Mendelian theory; they are generally compatible with the view that the head characters blend.

We fully admit that as yet our experiments do not admit of sweeping conclusions, they are not numerous enough at present, and not only are we not sure that all possible types of hybrids have so far occurred, but some of the most interesting types as the piebalds and skewbalds have not survived to maturity. But we have learnt enough to be sure that no simple form of Mendelian theory applies to the inheritance of coat colour in dogs still less to their head shapes. When an albino dog crossed with a black dog gives a black dog with white shirt front, or a chocolate dog with much reduced ocular pigmentation, it is not possible to use the term dominance, the first case is really particulate and the second possibly blended inheritance. When the crossing of two albinos may give a cream coloured puppy like themselves, or a marked skewbald puppy or a puppy with "a coat of a decided and uniform brown" all with albinotic eyes, when an extracted albino may be "lilac" with a white shirt front, it is too early to speak of albinism in man or beast as being a "unit character" and conformable with Mendelian laws. Dr Davenport in a recent memoir[1] asserts that albinism in man obeys Mendelian rules; his data however are sparse, and his investigation from the statistical, ophthalmological and microscopical standpoints very inadequate. As late as 1908, Professor Bateson in the Discussion on Heredity at the Royal Society of Medicine[2], remarked that he had shown pedigrees of albinism in man as an example of a character which did not follow Mendelian rules, but that those rules did apply to albinism in many animals. The writer of the article on Albinism in the *Encyclopaedia Britannica*[3], slips out of any apparent difficulty as to the "unit character" nature of albinism in the following manner:

> Among albino rats, for instance, the author of this article has reason to believe upon theoretical grounds resting on an experimental basis, that probably no less than thirteen types exist. With rabbits and mice there must be a still larger number.

Possibly in dogs then there may be 20 or 30! These would involve 210 to 465 different types of albino mating,—if there were only 13 varieties there would be no less than 91 possible matings—and each of these would produce different classes of offspring, and would require independent experimental work to determine their manner of inheritance. It is clear that if this be the real state of affairs Mendelism is not a theory which can *a priori* predict results, but a more or less cumbersome *a posteriori* description of observed facts. Nor is it easy to bring into accordance this diversity of albinotic type with Dr Davenport's application of simple Mendelism to albinism in man. As we have seen in the course of this work albinism is a graded character, and we have every reason to believe that both in man and dogs separate grades are hereditary. Further than this we should hesitate to go at the present stage of our experimental work. Mendelism is at present the mode—no other conception of heredity can even obtain a hearing. Yet one of the present writers at least believes that a reaction must shortly set in, and that the views of Galton will again come by their own. At any rate as far as we have gone at present the experiments on dogs seem to indicate that there is still a chance for philosophic Darwinism—*i.e.* the theory that small variations are continuously occurring and can be perpetuated by selection. Dr Eugene Fischer[1]—a distinguished anthropologist—has asserted that hybridisation has been demonstrated only to lead to a shuffling of pre-existing "unit characters," or in the words of Von Luschan, race mixture leads to race sorting out—"Rassenmischung zu einer Entmischung." The assumption made is that all hybridisation experiments prove that no stable intermediate is possible. We are not convinced that it will not be possible to perpetuate a race of dogs with a head index of 72, a muzzle index of 65 and a nose index of 33. Such a dog would possess characters which do not occur in either parent breed. It is too early yet to assume that nothing new can come into the world of mankind because, according to Dr Fischer, zoologists and botanists have answered by "thousands of hybridisation experiments that no new race is to be expected but only a shuffling of old unit characters."

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[1] *American Naturalist*, Vol. XLIV. p. 727, New York, 1910.

[2] *Proc. R. Soc. of Medicine*, Vol. II. 1909, p. 58.

[3] 11th Edition, Vol. I. p. 510.

The problem of whether philosophical Darwinism is to disappear before a theory which provides nothing but a shuffling of old unit characters varied by the appearance of an unexplained "fit of mutation" is not the only point at issue in breeding experiments. There is a still graver matter that we face, when we adduce evidence that all characters do not follow Mendelian rules. Mendelism is being applied wholly prematurely to anthropological and social problems in order to deduce rules as to disease and pathological states which have serious social bearing. Thus we are told that mental defect,—a wide term which covers more grades even than human albinism,—is a "unit character" and obeys Mendelian rules; and again on the basis of Mendelian theory it is asserted that both normal and abnormal members of insane stocks may without risk to future offspring marry members of healthy stocks[2]. Surely, if science is to be a real help to man in assisting him in a conscious evolution, we must at least avoid spanning the crevasses in our knowledge by such snow-bridges of theory. A careful record of facts will last for ages, but theory is ever in the making or the unmaking, a mere fashion which describes more or less effectually our experience. To extrapolate from theory beyond experience in nine cases out of ten leads to failure, even to disaster when it touches social problems. In all that relates to the evolution of man and to the problems of race betterment, it is wiser to admit our present limitations than to force our data into Mendelian theory and on the basis of such rules propound sweeping racial theories and inculcate definite rules for social conduct. Even if the offspring of an albino parent be themselves normal, we cannot advise them that all is safe if they marry into normal stock; for not only is Mendelism as yet undemonstrated for human albinism, but who shall determine what is "normal" stock, when over and over again the albino appears in the mating of two stocks which have no record of previous albinism?—Let us rather adopt the tone of the soothsayer in *Antony and Cleopatra* and when we are asked "Is't you, Sir, that know things?" reply modestly "In Nature's infinite book of secrecy a *little* we can read." We await the gradual building up of more complete knowledge.

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[1] *Handwörterbuch der Naturwissenschaften*, Bd. VIII. "Rassen und Rassenbildung," S. 91, Jena, 1913.

[2] Davenport, *Heredity and Eugenics*, p. 286, Chicago, 1912.

SECTION III. ACCOUNT OF THE INDIVIDUAL DOGS EXHIBITED IN THE PEDIGREE, PLATE LVII.

♂ = male, ♀ = female, ⚥ = unsexed.

Index No.	Sex	Name, Description, Ownership and Remarks.
I. 1	♀	*Mu Kwa*: colour unknown, belonged to Mr J. P. Bland, formerly of the Inspectorate General of Customs in Pekin, and is believed to have come from the Palace.
I. 2	♂	—?—: colour?, belonged to Mr J. P. Bland of Pekin.
II. 1	♂	—?—: colour?, a well-bred dog, belonged to Mr Bland, who gave him to Mr George Brown, 1894. Said to be from the Palace.
II. 2	♂	*Hsing Erh*: colour?, belonged to Mr Byron Brenan, Consul in China.
II. 3	♀	*Erh Shih I*: colour?, belonged to Mr Byron Brenan, Consul in China.
II. 4	♂	*Pekin Peter*: gray brindle, imported from Shanghai as a puppy in 1893 by Mrs Loftus Allen. Sire of Goodwood Meh, III. 9.
II. 5	♂	*Pekin Prince*: black with some white on chest and on left forefoot and toes of right forefoot. Imported by Mrs Loftus Allen, 1896, from the Palace. Portrait: see list p. 477, (6), p. 3.
II. 6	♀	*Pekin Princess*: all black, imported by Mrs Loftus Allen, at the same time as II. 5, with whom she was not known to be related.
II. 7	♂	*Huang tee*: fawn colour[1], black muzzle and dark eyes, son of I. 1 and 2, bred by Mr Bland in Pekin, and given by him to a member of Mr George Brown's family in 1887. Portrait from Mr Brown: see Plate φ (22) where name is given in error as Huangtu.
II. 8	♀	*Siao'rrh*: red and chestnut. Had belonged to the Dowager Empress, who presented her to a famous Chinese actor, by whom she was transferred to Mr George Brown, who brought her to England in 1894.
II. 9	♀	—?—: colour?, one of the Goodwood stock descended from the pair Guh and Meh[2] brought to England in 1860. Mother of Goodwood Meh: see p. 464.
III. 1	♀	*Fantails*: liver and white, very long ears, bred by Mr Bland in Shanghai about 1889 from I. 1 and II. 1; given to Mr George Brown and eventually went to Mrs Browning of Brackley; died in 1902, aged 13.
III. 2	♂	*Tarsa I*: colour? No details.
III. 3	♀	*Yangtse Kiang* or *Khan*: colour? Imported by Mrs Loftus Allen?
III. 4	♀	*Goodwood Queenie*: colour? Of the Goodwood stock of 1860.
III. 5	♀	*Pin-Kee*: fawn, or pale yellow, and white, black eyes. Bred by Mr George Brown in Kewking from II. 7 and 8, brought by him to England in 1895, and owned by him all her life. Portraits from Mr George Brown.
III. 6	♂	*Ah Cum*: chestnut or bright sable red with dark brown eyes; imported with III. 10 by Mr and Mrs Douglas Murray from the Palace in 1896, aged about 12 months, weighing 5 lbs. Died in 1906, is set up as a typical specimen in the British Museum (Natural History). Portrait (2), frontispiece (6), p. 1. Owing to the courtesy of the Museum authorities we have been able to examine microscopically some of the hairs of this dog. The hairs from the back are of three kinds: (*a*) light hairs, these have light yellow diffused pigment and small but fairly plentiful granules; (*b*) red hairs, bright orange yellow diffused pigment, small but plentiful granules; (*c*) black hairs, very dark diffused pigment, extremely densely packed granules. In the hairs from the foreleg there were no diffused pigment and no granules. If the reader compares these results for the hairs of Ah Cum with those for the Pekinese Spaniels given on p. 344, he will see that many others of these dogs have a closer approach to albinism of the hair, even with similarly coloured coats.
III. 7	♀	*Chin*: colour?, probably imported; no details.
III. 8	♂	*Goodwood Yuh*: colour? Of the Goodwood stock.
III. 9	♀	*Goodwood Meh*: mahogany red with black face. Sire Pekin Peter II. 4, dam II. 9 of the Goodwood stock, name not ascertained.
III. 10	♀	*Mimosa*: red sable, imported, with III. 6, by Mr Douglas Murray, 1896, and at about same age, weighed 3 lbs. It is suggested by a lady who knew both that Ah Cum and Mimosa were brother and sister, but no one really knows. She is related as a mate of Ah Cum to the albinos. Portrait: see list p. 477, (2), frontispiece; (6), p. 1.

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[1] The hair of this dog seems to have been similar to that of Mr George Brown's dog Pailee (see Plate φ (25), where as on p. 468 the name is unfortunately printed Pailu) of whose hair we have, owing to Mr Brown's kindness, specimens from October 12, 1911, and from several years earlier. They contain no granules, and such dogs with black muzzles and dark eyes may be said to be true albinos as regards the coat.

[2] Portraits, p. 14, 2nd ed. L. C. Smythe's *The Pekingese*.

Index No.	Sex	Name, Description, Ownership and Remarks.
IV. 1	♀	*Nika*: colour? No details.
IV. 2	♂	*Tarsa II*: colour? No details.
IV. 3	♀	*Chiusan*: colour? No details.
IV. 4	♂	*Pekin Paul*: fawn or fawn brindle, son of the black pair II. 5 and 6. Portrait (8) 1st Ed. p. 85, 2nd Ed. p. 75.
IV. 5	♀	*Mali*: colour? No details.
IV. 6	♀	*Tai-Tai*: colour? No details.
IV. 7	♂	*Poo-Sa*: dark mask and good deal of colour in coat, portraits from Mr George Brown.
IV. 8	♀	*Ching Vih*: colour? No details.
IV. 9	♀	*Wang*: colour? No details.
IV. 10	♀	*Shui*: colour? Bred by owner of her parents, III. 6 and 10.
IV. 11	♀	*Valeria*: colour? Daughter of Ch. Goodwood Chun VI. 6 and Cottesmore Chin VIII. 2.
V. 1	♂	*Brackley Erh Shi*: colour? No details.
V. 2	♀	*Pekin Pu Chun*: colour? No details.
V. 3	♀	*Sannie-Tannie* (?): colour? No details.
V. 4	♂	*Ch. Put Sing*: colour? Sole issue of Goodwood Queenie, III. 4. No skin or hair sample of Goodwood Lo has been preserved, but through the kindness of Lady Blanche Gordon Lennox we have obtained hair samples of Goodwood *Put Sing*, V. 4, who was still alive in September 1911. He was father of Goodwood Chun. Put Sing is of the original Goodwood shade—a lightish sable with golden tinge, and this was the colour of Goodwood Lo from whom the albinos spring. In the case of the hairs sent of this dog we have: (*a*) dark hairs, deep brown diffused pigment densely packed with granules (ζ); (*b*) yellow hairs, yellow diffused pigment, plenty of granules (δ); (*c*) pale hairs, slight diffused pigment and a decided number of granules (γ), the palest hairs have practically no diffused pigment, but assuming these results to hold for Goodwood Lo, there is nothing especially albinotic about the coats of the Goodwood dogs of the original Goodwood shade, they are as normal as that of Ah Cum (see III. 6, above) and far more so than some of the fawn coloured dogs (see p. 344 above). We have also investigated the hair of Palace Yen a grandson of Goodwood Lo by Roma (see footnote, p. 462), his sire, Palace Pao-Chen, being whole brother of Mi-Mei. His coat is described as "pale biscuit," but contains black, yellow and white hairs mixed. The black hairs have dark brown diffused pigment and are thickly studded with brown granules (ζ). The yellow hairs have bright lemon diffused pigment, with a decided number of small brown granules (γ). The white hairs have no diffused pigment and no granules. There is therefore nothing to mark Palace Yen, any more than Put Sing, as closely approaching albinism of the coat.
V. 5	♀	*Ching'rrh*: red.
V. 6	♂	*Tau Chi*: colour? No details.
V. 7	♂	*Chifu*: colour? No details.
V. 8	♀	*Fai*: colour? No details.
V. 9	♀	*Goodwood Nala*: colour?, died after birth of her only puppy, Ch. Goodwood Chun (VI. 6).
V. 10	♂	*Goodwood Ming*: dark red or chestnut, born July 12, 1900.
V. 11	♀	*Lady Ming*: red, born March 8, 1899.
V. 12	♀	*Fan-tan of Braywick*: colour?, still alive, 1911.
V. 13	♂	*Chang Pu Chong*: colour? No details.
V. 14	♀	*Pan Hura* (? spelling): colour? No details.
V. 15	♀	—?—: colour? No details. Imported.
V. 16	♂	—?—: colour? No details. Imported.
V. 17	♀	*Lady Annie*: colour? No details.
V. 18	♀	*Pekin*: colour? No details. Imported.
V. 19	♂	*Smut*: colour? No details. Imported.
V. 20	♂	*Boxer*: colour? Imported by Major Gwynne. Portrait: see list p. 477, (6), p. 8.
V. 21	♀	—?—: colour? Imported by Major Gwynne, mate of V. 20 and mother of Poongi, VI. 18, who is also said to have been imported.
V. 22	♂	*Ch. Goodwood Lo*: red[1] with black mask and dark eyes, a very celebrated dog that belonged to Mrs Douglas Murray, a son and probably first issue of Ah Cum, III. 6 and Goodwood Meh, III. 9. Born 1896 or 7, died 1910 or 11. Portrait: see list p. 477, (8) 1st Ed. p. 96.
V. 23	♂	*Goodwood Cheng*: colour? Another son of III. 6 and 9.

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[1] Lady Blanche Gordon Lennox speaks of Goodwood Lo as of the original Goodwood shade, light sable with golden tinge. See V. 4.

Index No.	Sex	Name, Description, Ownership and Remarks.
V. 24	♀	*Ah-lu-ta*: gold sable or red, black mask and long black fringes to ears. Born September 23, 1900, died 1910 or 11. Daughter and granddaughter of Ah Cum, III. 6 and granddaughter of Mimosa, III. 10, but not related to Goodwood Meh, III. 9. She was mother of the first series of albinos, their father being Goodwood Lo, V. 22.
V. 24*a*	♀	*Roma*: colour pale cream, with white feet, brown eyes and black nose. Imported from Canton by Mrs Douglas Murray; see p. 462 footnote. We have been able to examine some of the hairs of Roma. There are two kinds, white having no diffused pigment and no granules; yellow, having a pale yellow diffused pigment, in these hairs there are one or two granules but very few. Thus as far as the coat is concerned Roma is far more albinotic than Ah Cum, III. 6, or Put Sing, V. 4, but not quite so albinotic as Mr George Brown's dogs Huang tee, II. 7 or Pailee: see footnote p. 462.
V. 25	♀	*Petsche Yen-Tai*: colour? Dam, Lady Ming, V. 11, and sire, Ch. Goodwood Chun, VI. 6. No details ascertained.
VI. 1	♀	*Woodbury Lung Lu*: colour? No details.
VI. 2	♂	*Shansee*: colour? No details.
VI. 3	♀	*Ping Shang*: colour? No details.
VI. 4	♀	*Gia-Gia*: red brindle, a well-known dam. Portrait: see list p. 477, (3), p. 22.
VI. 5	♀	*Kau Tien*: colour? No details.
VI. 6	♂	*Ch. Goodwood Chun*: dark coat, white chest and some white on forefeet[1], only issue of Goodwood Nala V. 9. Born August 1, 1901. Portrait: see list p. 477, (3), p. 29, (6), p. 13, (8) 1st Ed. p. 34, 2nd Ed. p. 118.
VI. 7	♀	*Palace Luk Shan*: colour? No details.
VI. 8	♀	*Palace Tong Shan*: colour? No details.
VI. 9	♂	*Prince Kwang of Roydon*: colour? No details.
VI. 10	♀	*Yalu*: colour? No details.
VI. 11	♂	*Shung ti*: colour? No details.
VI. 12	♂	*Peiho*: colour? No details.
VI. 13	♀	*Fi-Fi*: colour? No details.
VI. 14	♀	*Mi Joie*: colour? No details.
VI. 15	♂	*Augustus*: colour? No details.
VI. 16	♀	*Kali*: colour? No details.
VI. 17	♂	*Glanbrane Fu*: colour? No details.
VI. 18	♀	*Poongi*: all black, her tail is docked. Imported with her father, V. 20. Portrait: see list p. 477, (6), p. 8.
VI. 19	♂	*Tien-Ta-jen*: colour? No details.
VI. 20	♂	*Palace Pong*: albino, the first to appear in our pedigree; reported by Mrs Benett Stanford as "absolutely white" in coat, eyes "white or light blue," nose pink. He was (as some other albinos) a very large specimen of the Pekinese breed. Born September 1901; dead in August 1911, at time of inquiry. Sire, Goodwood Lo (V. 22) and dam Ah-lu-ta (V. 24).
VI. 21	♀	—?—: red, black face, coloured sibling of Palace Pong.
VI. 22	⚲	—?—: red, black face, coloured sibling of Palace Pong.
VI. 23	♀	*Palace Tzu*: red, black face, coloured sibling of Palace Pong.
VI. 24	♀	*Palace Ping*: albino, the second to appear, reported as "pure albino absolutely white" (Mrs B. Stanford). Born in 1902, of same parents as Palace Pong.
VI. 25—29	⚲	—?—: all coloured, five siblings of Palace Ping.
VI. 30	♂	*Unnamed*: albino, born of same parents as Palace Ping, March 2, 1904.
VI. 30*a*	♀	*Unnamed*: red, sibling of VI. 30.
VI. 31	♀	*Palace Neh*: albino, very white, sibling of VI. 30 and 30*a*.
VI. 32	♂	*Palace Hia*: albino, born with his five litter-siblings, September 7, 1904, of Ah-lu-ta (V. 24) by Goodwood Lo (V. 22).
VI. 33	♂	*Palace Tai-li Fu*: red with black muzzle, alive in 1910.
VI. 34—37	♂, ♂, ♂ and ♀	—?—: coloured dogs, litter-siblings of Hia (VI. 32) and Tai-li Fu (VI. 33).
VI. 38	♂	*Ping Pong*: red.
VI. 39	♂	*Palace Fei Noo*: albino.
VI. 40	⚲	—?—: albino, unsexed, litter-sibling of VI. 39.

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[1] Judged from portrait.

Index No.	Sex	Name, Description, Ownership and Remarks.
VI. 41—43	⚲, ⚲, ⚲	—?—: coloured, unsexed, litter-siblings of the albinos VI. 38 and 39.
VI. 44—45	⚲, ⚲	—?—: coloured, unsexed. A litter of two with no albino from Ah-lu-ta (V. 24) and Goodwood Lo (V. 22). Born 1906.
VI. 46	♂	—?—: black, imported 1907, name not obtainable.
VI. 47	♀	*Palace Wan-li*: chestnut red, with brown not black nose, and face not black. Born August 21, 1905, her dam Lady Ming, V. 11, and sire Ch. Goodwood Chun, VI. 6.
VI. 48	♀	*Woo-la-lu*: colour?—Her sire was Peiching Pagoda, and her dam Woo-lu, both sired by Ch. Goodwood Chun, VI. 6.
VI. 49	♂	*Peiching Pakling*: colour? Sire Pekin Paul, IV. 4; dam Valeria, IV. 11, who was a daughter of Ch. Goodwood Chun, VI. 6, and Cottesmore Chin, VIII. 2. Portrait: see list p. 477, (8), 1st Ed. p. 84.
VI. 50	♂	*Pekin Yen*: red, imported by Sir Edward Boehm, belonged later to Lady Gooch.
VII. 1	♀	*Brackley Chinchilla*: presumably chinchilla. No details.
VII. 2	♀	*Lessingham Ling Lu*: black and tan.
VII. 3	♀	*Ping Sheng*: no details sought.
VII. 4	♀	*Tee Bah of Radnage*: no details sought.
VII. 4 *a*	♀	*Manchu Pao'en*: no details sought.
VII. 5	♂	*Pekin Pom*: no details sought.
VII. 6	♀	*Palace Kwa-Haing*: no details sought.
VII. 7	♀	*Amoy*: no details sought.
VII. 8	♂	*Ch. Manchu-Cheng-tu*: Portrait: see list p. 477, (3), p. 27. No details sought.
VII. 9	♀	*Lady Min of Roydon*: red, black markings, born July 13, 1901.
VII. 10 *a*	♂	*Payching Chong*: no details sought.
VII. 10 *b*	♀	*Fi-Fa*: no details sought.
VII. 11	♂	*Glanbrane Li*: fawn.
VII. 12	♂	*Taps*: colour? No details.
VII. 13	♂	*Glanbrane Black Chu*: black presumably.
VII. 14	♂	*Glanbrane Lung*: all black. Portrait: see list p. 477, (6), p. 8.
VII. 14 *a*	♂	*Wang Chia Ting of Alderbourne*: "Silver Brindle or Biscuit." Born January 24, 1905. Portrait: see list p. 477, (3), p. 33. He sired the first litter of the albino Tong I (VII. 17). His granddams were Cottesmore Fi-Fi (not our VI. 13) and Gia-Gia, VI. 4. Grandsires were Goodwood Ming, V. 10, and Ch. Goodwood Chun, VI. 6. Cottesmore Fi-Fi was got by Prince Kwang of Roydon, VI. 9, out of Ping Shang, VI. 3.
VII. 15	♀	*Ch. Palace Shi*: Portrait: see list p. 477, (3), pp. 22 and 25.
VII. 16	♂	*Mia of Alderbourne*: bright red, no white, born May 21, 1905.
VII. 16 *a*	♀	*Moa-Ti*: black, belonged to Mrs George Brown.
VII. 17	♀	*Tong I*: albino, belonged in succession to Mrs Franklin, E. Nettleship and Karl Pearson. One of our foundation stock. For portrait at 4—5 years old: see Plate *v* (1). She was rather a large specimen, larger than her albino mate Jack, X. 9, but not nearly as large as her son Wee Ling, XI. 31. Decidedly whiter than the albinos, X. 9 and 10 and their offspring; there was some cream colour on back and ears, but none of her hairs contained any granules. She had dark brown "spectacle marks" and the hairs between her paws would grow red, if she perspired in taking exercise. But neither paw hairs nor those of spectacle marks contained any pigment granules and the latter would almost entirely disappear if she was kept indoors with her litters. She was an excellent mother, but not so playful as some of the other albinos. She went to Karl Pearson, when a relatively old dog (four years) and soon became extremely affectionate. She was very nervous, and would fly home, if she met a cart-horse in a narrow lane; later she usually went out with a male dog, and would then pass anything and join battle with strange dogs. On the whole she was the most nervous and least pugnacious of the albinos Karl Pearson has had. She had considerable selfwill, but was more obedient than most of her offspring, and did not pursue cattle or follow game or cats. She had seven litters and upwards of 30 puppies. Five litters, VIII. 23 *a—d*, 16, 17, 18—22, 23, from coloured dogs, with all coloured offspring, and two litters by the albino, X. 9, all albinos. Later, she developed an internal tumour and became so ill that it was found best to destroy her by chloroform early in 1911, aged 6½ years. A full microscopical report of her eyes will be found on p. 362 above, and of her internal organs on p. 405. Neither hair, skin nor any of the organs except the eye showed any trace of melanin pigment[1].

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[1] Hairs of Tong were frequently examined. Hair from her ear, a somewhat darker part, showed after her death absolutely no granules.

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VII. 17—22	4 ♀s, 2 ♂s	Tong I and her litter-siblings, two males and four females, all albinos, born August 24, 1904, of the two albinos VI. 20 and 24. The names of four of these albinos, VI. 18, 19, 21, 22, are unknown, and we have not been able to trace any of their descendants, nor what became of these albinos.
VII. 20	♀	*Ting I*: albino, one litter known, leading to an isolated albino grandchild.
VII. 23—29	2 ♀s, 5 ♂s	Litter of seven albinos, born September 7, 1905, of the same albino parents, VI 20 and 31, as VII. 17–22. No breeding record of any but VII 29. One male belongs to Dr Fisher, brother to Mrs Mark Mayhew.
VII. 29	♂	*Ching*: albino of the above litter; one litter of his offspring is known; belongs to Mrs Mark Mayhew.
VII. 30—33	1 ♂, 3 ♀s	Litter of four albinos, born July 14, 1900, parents both albinotic, the three females died young, the male survived, but his career not recorded.
VII. 34—38	1 ♂, 4 ⚲s	Litter of five, one male and two unsexed albinos, two unsexed red colour. Born December 6, 1905. No descendants recorded. Dam, albino, VI. 31, and sire a red dog, Ping Pong, VI. 38.
VII. 39—42	4 ⚲s	Litter of four, unsexed, born about 1907, all red offspring of a very white albino mother, Palace Ping, VI. 24, and a black father, VI. 46, said to have been imported in 1907.
VII. 43	♂	*Wen ti*: pure black, no white hairs. Born, May 26, 1904, bred by Mrs George Brown. He was mated with the two albinos Tong I, VII. 17, and Ting I, VII. 20, producing red or black offspring.
VII. 44	♂	*Togo* (?): red, mated with Tong I (VII. 17) and giving an all red litter.
VIII. 1	♂	*Brackley Kin Chau*: red brindle, no white. Portrait: see list p. 477, (8), 2nd Ed. p. 120.
VIII. 2	♀	*Cottesmore Chin*: colour? No details sought.
VIII. 3	♀	*Suh Nan*: golden red.
VIII. 4	♀	—?—: no details known.
VIII. 5	♀	*Kau Tien Soo Soo*: no details sought.
VIII. 6	♂	*Manchu Tao Tai*: chestnut.
VIII. 7	♂	*Goodwood Ching*: colour? No details.
VIII. 8	♀	*Ching'rrh*: colour? Same as V. 5.
VIII. 9	♂	*Liao Wang*: ? No details.
VIII. 10	♀	*Manchu Wei Wei*: dark red.
VIII. 11	♀	*Cottesmore Wotah*: ? colour. No details sought.
VIII. 12	♂	*Chong of Braywick*: red, born September 20, 1904.
VIII. 13	♀	*Lwla*: colour? No details sought.
VIII. 14	♀	*Dorothy*: colour? No details sought.
VIII. 15	♀	*Glanbrane Chinita*: pure black bitch, mated with the albino Ching, VII. 29, she produced nearly black puppies IX. 9—11.
VIII. 16	?	Second litter of Tong I, the albino, VII. 17, by the silver brindle dog Wang Chia Ting, VII. 14 *a*, all red with black faces; exact number, sexes and date not recorded.
VIII. 17	5 ⚲s	Third litter of Tong I, the albino, VII. 17, by Mia of Alderbourne, VII. 16, a bright red dog with no white. Sexes not recorded, but all five were red. It should be noted that Mia's sire, Manchu Tao Tai, VIII. 6, and dam Manchu Wei Wei VIII. 10, both contain blood of Ah Cum, III. 6, and Meh, III. 9.
VIII. 18—22	1 ♂, 3 ♀s, 1 ⚲	Fourth litter of Tong I, the albino, VII. 17, also by Mia VII. 16. One unsexed died in infancy. All red. VIII. 19—20 untraced.
VIII. 21	♀	*Ting of Noke*: chestnut red with black mask. She was mated with the similarly coloured Kara, IX. 3, and produced the albino, X. 20, Spook, now in C. H. Usher's possession.
VIII. 22	♀	*Pykta*: red, died in whelping with her 1st litter.
VIII. 23	4 ⚲s	Fifth litter of Tong I, the albino, VII. 17 by VII. 44, a red dog, all four puppies were red, sex not recorded.
VIII. 23 *a*—*d*	1 ♀, 3 ♂s	First litter of Tong I, the albino VII. 17, by the pure black dog Wen ti, VII. 43, all the offspring were red.
VIII. 24	♀	*Nannie*: black. Not registered in this name, said to be descended from Goodwood Lo, V. 22. Belongs to Miss Carter.
VIII. 25—26	5 ⚲s, 1 ♂	*Billy*: a black dog, and five litter-siblings. They were the offspring of the albino bitch Ting I, VII. 20, and the black dog, VII. 43, Wen ti. Billy and Nannie produced the "extracted recessive," IX. 12, an unsexed albino.

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VIII. 27	♂	*Pekoe*: colour? No details obtainable.
VIII. 28	♀	*Loona*: colour? No details obtainable.
IX. 1	♀	*Broad Oak Betty*: colour? No details.
IX. 1*a*	♂	*Woo-te of Toddington*: see X. 8*a*.
IX. 1*b*	♀	*Chinkee*: colour? No details.
IX. 2	♀	*Puff-Puff*: colour? No details sought.
IX. 2*a*	♀	*Wi Wi of Alderbourne*: colour? No details sought.
IX. 3	♂	*Kara*: dark red with black mask.
IX. 4	♂	*Wong Sing of Braywick*: deep red with dark shading; born May 20, 1906.
IX. 5	♀	*Wa Wa*: colour? No details sought.
IX. 6	♂	*Ch. Chu-êrh of Alderbourne*: coloured general coat, dark mask, some white (or light colour) on front of neck and feet. Portrait: see list p. 477, (3), p. 29, (8) 1st Ed. p. 47, 2nd Ed. p. 57.
IX. 7	♀	*Patty of Braywick*: "red and white" or "brindle and white."
IX. 8	♀	*Woo-How of Toddington*: colour? No details sought.
IX. 9	♂	*Gollywog*: a nearly black dog, the issue of the albino Ching, VII. 29, and the perfectly black bitch Chinita, VIII. 15. Both VII. 29 and VIII. 15 are seen to be related to III. 6 and 9. Gollywog was 2 years old when seen in December, 1909: his coat generally looked black and most of it was black, but in some parts, chiefly where the coat was longest, many of the hairs were of a very dark brown with reddish tinge; over the sternum between the forelegs was a large "blaze" of pure white and there were some pure white hairs between the toes of each forefoot. Gollywog's sexual organs were no more developed than those of a young puppy, and he was impotent.
IX. 10 and 11,	2 ♀s	Gollywog's siblings, IX. 10 and 11, were not seen, but they were said to be as nearly black as he was, and had no white hairs anywhere.
IX. 12	⚲	Albino, with red nose, albinotic eyes and yellowish coat; seen in the street, but no full inspection possible: clue obtained as to its breeder and parents VIII. 24 and 25 only.
IX. 13		Coloured litter-siblings of IX. 12.
IX. 14	♀	*Wen*: colour? No details.
X. 1	♂	*Minoru*: red, no white; small well-made dog, selected on account of colour and being only distantly related to III. 6 and 9 for mating with the albino bitch, XI. 25, Tong II. He also sired a puppy with nystagmus, XI. 1.
X. 1*a*	♀	*Vinney of Wykham*: colour? No details.
X. 2	♀	*Chu Chu*: colour? Mother of puppy with nystagmus.
X. 3	♀	*Huan Hsi of Noke or Pekoe of Noke.* Colour? No details.
X. 4—6	—	Several litters by Wong Sing of Braywick and various coloured bitches (the first being Fan-tan of Braywick, V. 12); no puppy in these litters had nystagmus and none were albinotic.
X. 6*a*	♀	*Nell of Winkfield*: colour? No details.
X. 7	♂	*Howbury Choo Tai Tsoo*: colour? No details sought.
X. 8	♂	*Wong ti of Alderbourne*: colour? Portrait: see list p. 477, (8), 1st Ed. p. 48.
X. 8*a*	♂	*Woo-te of Toddington*: red, black markings.
X. 9—13		Litter with two albinos and one nystagmic dog.
X. 9	♂	*Jack*: albino, born November 1907, foundation stock of our breeding experiments. See on this page below.
X. 10	♀	*Jill*: albino, litter sister to Jack, foundation stock. See p. 498 below.
X. 11	⚲	Name unknown; red with black nose, litter-sibling of Jack and Jill.
X. 12	♂	*Wee Wong of Westbury*: red with black nose, prize, aet. 7 months. Portrait: see list p. 477, (8), 2nd Ed. p. 41, shows a distribution of white or very light colour on hind leg and forefoot like that of his albino nephew Fo, XI. 10. Litter-sibling of Jack and Jill.
X. 13	♂	*Unnamed*: red with black nose, died of "gastritis" at the age of about 12 months. Nystagmus. Litter-sibling of Jack and Jill. The sire of X. 9—13, or IX. 4, was of deep red with black shading, he was born May, 1906, and this litter, born November, 1907, was the first he sired; the dam, IX. 7, has been variously described as "red and white" and "brindle and white."
X. 9—10		Description. Jack and Jill came into the possession of E. Nettleship in November, 1908, when just a year old; their photographic portrait taken two or three months before is reproduced as Fig. 113 on Plate JJ. Plate *v*, Fig. 15, was taken a day or two after they arrived and Figs. 10, 11, and 14 are from photographs taken in August and September, 1911. Jack has always been much larger than Jill. His

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weight on October 13, 1911, was just under 14 lbs., and Jill's at the same date a little over 10 lbs. The fringes of Jack's ears and featherings of hind legs and feet are not so long as Jill's, but in other features the pair are extremely alike. Jack's coat is pure white on chest and front of neck, pure or all but pure white on belly, back of neck and all four limbs, a moderate cream colour on the back from shoulders and along the greater part of length of tail; the "colour"[1] is rather more marked in front and behind root of tail than elsewhere on the trunk. The mask, chin and ears are somewhat more "coloured" than the back, and the "spectacle mark" is and in this dog has always been strongly emphasised; it varies but little but is at times more marked on the side of the more susceptible, the left, eye. Nose, skin and all visible mucous membranes quite pink and showing no visible trace of pigment. Between date of purchase and the present date has had one attack of slight ulceration of cornea in both eyes, and has had many attacks of diffuse keratitis in L. eye without further ulceration since; the relapses have usually come on after exposure to high wind, especially if temperature is low. He is extremely active, vivacious and courageous, but is nervous as is shown by his starting or jumping up at unexpected noises, and sometimes snapping, without seeming to be unfriendly, at strangers. Sense of smell very good, and hearing probably as good as in other dogs. Sight is decidedly defective; does not recognise people he knows nearly so far off as do coloured dogs of other breeds, but there has been no opportunity of comparing him in this respect with coloured Pekinese; when running fast has often come up against obstacles,—a step, a footstool, or, out of doors an inequality in the ground,—that ordinary dogs would certainly have recognised. There is a failure of stereoscopic vision. He dislikes strong light; the L. eye (the unsound one) weeps on the average more than the R. and both weep rather more than the other dogs' eyes, and produce a good deal of mucus; eyelids and lashes normal. The initial ulceration of cornea was probably due to some error in diet, for he has never had another and is in all other respects strong, hardy, unaffected by changes of season and temperature and goes out in all weathers. Irides very pale blue, near pupil almost white with a yellowish, or very pale buff, tinge towards periphery; pupils pink in some lights, black in others. He has sired seven litters containing in all 24 puppies, two litters of five each, one of four, two of three, and two of two each.

Jill, X. 10, has long fringes to her ears, long feathering to hind legs and long hairs down to the toes; the distribution of the cream tint in her coat is practically the same as in Jack, but there is as a rule rather less colour; twice when pregnant and suckling puppies we thought the coloured parts of her coat became decidedly darker; and in September and October, 1911, after weaning her puppies of 4th August, there was not the slightest doubt that her coat darkened on the back and sides. This darkening of her normal cream colour is limited to the part of the hair furthest from the skin, the deeper parts of the coat being white or nearly so. When she first came she had almost as dark a "spectacle mark" as Jack (see Fig. 15, Plate *v*, taken November, 1908), but this has gradually diminished both in size and depth of colour and is now very slight. Soon after her arrival in November, 1908, her R. eye was wounded by another and much larger bitch who was jealous of her (Tong 1st, VII. 17), the wound suppurated and the eye eventually shrank to a mere stump which has given no further trouble. It may be noted that the "spectacle mark" was noticed to be diminishing on the lower lid of the lost (R.) eye before any change was observed on the L. side, and it is still a little more visible on the L. lid than the R. Her eyes, like Jack's, secrete a good deal of mucus and tears. She is more excitable, irascible and affectionate than Jack, but also cleverer in gaining her ends and a great coquette. She is perfectly hardy, sleeps in an out-door shed when necessary, and is out in all weathers. She has mated six times with her brother Jack; the first was a missed conception, the other five yielded respectively two, five, two, four, and four puppies, and of these four were still-born, six died within two months of birth, and one had to be killed at six months; six grew up, one of whom was killed by an accident; the five surviving seem healthy dogs. The mortality has thus been rather great. All her grown puppies are larger than she is, especially the males, some being quite as large as, if not larger than, the father. They are all albinos: see XI. 5—17 and *f*—*i* below.

X. 14 ♀ *Ching*: colour? No details sought.

X. 15 ♀ *Ta-ti*: colour? No details sought.

X. 16 ♂ —?—: colour? No details sought.

X. 17 ♂ *O-lo-Peen of Toddington*: dark red sable, black mask, dark eyes, born September 1, 1906. Portrait (6), p. 9, and (8), 1st Ed. p. 92; belongs to Mrs Hugh Andrews.

X. 18—19 2 ♂s Two litter-siblings of the albino Spook, X. 20. They were born November or October, 1909. Both red.

X. 20 ♀ *Spook*: albino. It will be seen that she was a granddaughter of the albino Tong I, VII. 17, her mother being Ting I, VIII. 21, and her sire Kara, IX. 3. Spook is almost pure white, more nearly so than any other albino Pekinese we know, having less cream than her maternal grandmother, Tong I. Pupils exceedingly red. During the few weeks in 1910 that E. Nettleship had her, before she went to

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[1] It seems erroneous to call this "colouring" a pigment, by which we generally infer the presence of pigment granules. In the hairs of these dogs, including the "spectacle marks," it appears due to lipochromes.

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		C. H. Usher, she was exceedingly restless and constantly barking. She had previously been in a smaller kennel, and with a much larger number of dogs, but want of congenial company did not seem a sufficient explanation of her behaviour. C. H. Usher mated her with an albino, Donald ban, XII. 18, son of his two albinos, Mairi bhan and Ian ban, XI. 26 and 27. The result was five albino puppies, XIII. 1—5, born December 20, 1910. The dam, Spook, was 13 months and the sire 12 months old; two died almost at birth, and Spook worried and almost killed all the other three at various dates during the nursing period, so that none grew up. She had a second litter, XIII. 6—10, of five albinos by the same sire, on July 16, 1911, and killed or maimed the three females that were already puny and perhaps would not have grown up; the two males survived, being taken away from her. She had a third litter of three, X. 11—13, of whom none survived. Of her last litter of five (born March 29, 1913) by a black Pomeranian two only were left with her; one of those given to a foster-mother died or was killed a month later. She is still, probably, the whitest of all our albinos, and the "spectacle marks" are but feebly shown; see Plate *v* (9).
X. 20*a*	♀	*Palace Mi Mei*: golden sable, belongs to Mrs Douglas Murray: see p. 462 footnote and Roma, V. 24.
X. 21	♀	*Whitey*: albino. It will be noted that her sire is litter-sibling to the albino, VI. 33, while her dam is a daughter to V. 22, Goodwood Lo, so she is descended from the albinotic stock on both sides. Not known whether she had any litter-siblings.
X. 23	♀	*Garnons Meh*: colour ?, mother of Little Oo. No details.
XI. 1	♂	*Unnamed*: light red, black muzzle, dark brown irides at 4 months, died soon after; nystagmus.
XI. 2—3,	2 ♀s	Siblings to XI. 1, without nystagmus and similarly coloured.
XI. *a*	♀	—?—: albino, belonging to Mrs E. E. Lowes.
XI. *b*—*c*	♀, 2 ⚲s	An albino bitch and two coloured unsexed dogs, litter-siblings of XI. *a*, which all died at birth.
XI. *d*	♀	—?—: coloured, litter-sibling of XI. *a*, which was alive February 1913.
XI. 4	♂	*Hanuman of Noke*: dark red, black mask, white chest and feet.
XI. 4*a*	♂	*Sutherland Hi Yang*: colour ? Father of C. H. Usher's albino, Beenie, XII. 16*a*.
XI. 4*b*	♀	*Chun Lung of Wykham*: colour ? Mother of C. H. Usher's albino, Beenie, XII. 16*a*.
XI. *f*—*i*,	3 ♀s, 1 ♂	Fifth litter of Jack and Jill, four albino puppies, born July 27, 1912.
XI. *f*	♀	*Peggy*: albino, the only survivor; a good-natured nice puppy with, from the Pekinese standpoint, too large a nose; light coat with some pure white, *e.g.* at tip of tail; given away at 8 weeks old.
XI. *g*	♀	*Unnamed*: albino, found dead about seven days after birth, when she seemed doing well; no post-mortem.
XI. *h*	♀	*Unnamed*: albino, lived nearly three weeks; much smaller than Peggy, and was pushed about by her, but when Peggy was removed did not suck well; taken about 7—10 days into house and fed by bottle; kept in cotton wool; still did not suck well and more than once turned "blue" and was thought to be dead some days before actually dying. Post-mortem: large communication between R. and L. auricles of heart—patent foramen ovale. Death probably due to pathological imperfection of inter-auricular septum; no other evident disease.
XI. *i*	♂	*Unnamed*: albino, born dead or suffocated by mother; big puppy, well formed; coat, as in some of these new-born albino puppies, light brown all over except a pure white "shirt-front" over sternum.
XI. 5—6	2 ♂s	Jill's first litter from Jack, born July 29, 1909. Two albinos.
XI. 5	♂	*Unnamed*: albino, died at birth, not seen, E. Nettleship being away, but said to have a dark mark down the back.
XI. 6	♂	*Wang*: albino, grew to a good size; coat of the rather dark cream type. "Spectacle marks" hardly indicated at 3½ months old, but appeared later. Portrait, Plate *v* (17). For examination of hair see p. 344 above. Living and well March, 1913, when loaned to K. Pearson for mating purposes.
XI. 7—11	3 ♂s, 2 ♀s	Jill's second litter by Jack, born January 28, 1910.
XI. 7	♀	*Unnamed*: albino, coat nearly white, very slight yellowish or fawn tinge, small and puny, died of inanition aged 21 days. Microscopical sections of eyes show complete absence of stroma pigment in iris, ciliary body and choroid. Epiblastic layer (retinal pigment epithelium) of iris lightly pigmented; the pigment yellowish brown and sparse enough to allow the nuclei to be easily seen; same for outer layer on ciliary body, where however the pigmentation is more abundant. On iris the posterior or inner layer of cells much less pigmented than the anterior or outer[1] and rather more towards root than

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[1] This difference between the quantity of pigment and granules present in the two layers of the epiblastic stratum on back of iris, the posterior or inner layer less pigmented than the anterior or outer, was also found, although less strongly marked, in the iris of a perfectly black Retriever puppy just four weeks old. The relative paucity of pigment in the posterior or inner layer is most evident, in all the albino eyes above described, towards the periphery or root of the iris; here the posterior or inner layer of epiblast passes on to the ciliary body and is always devoid of pigment. In regard to the presence or absence of traces of pigment in the various parts of these albinotic Pekinese puppies' eyes I may say that when in doubt I compare them with sections of the eye of a perfectly white albino rabbit made by Mr Coats, in which not the faintest trace of pigment can be found. (E. N.)

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towards pupillary border. Epiblastic (hexagonal pigment epithelium) layer on choroid shows a few yellow brown granules very sparsely scattered from ora serrata about as far as equator, none at all nearer to optic disc.

XI. 8 ♀ *Fi*: albino, grew and thrived well but when a few weeks old showed weakness of L. hind leg which after a time became somewhat wasted and contracted and as she got older hampered her exercise and prevented her getting her share of food with the other dogs. Showed signs of "heat" early in August (aged about 6 months) and not having a hopeful future was destroyed (prussic acid) on 10th. Portrait, Plate ϕ (19) and (21). Eyes and entire skin kept, also skull for the bones; lower jaw longer than the upper like her mother Jill. Coat almost white from birth, but yellowish or cream on dorsal aspect of trunk and frontal region; "spectacle marks" small but perfectly well indicated beneath the inner or anterior corner of each lower lid.

Microscopical examination of the eyes showed entire absence of stroma pigment in iris, ciliary body and choroid. Epiblastic layer of iris lightly pigmented, the nuclei being visible; corresponding outer layer on ciliary body more pigmented so as just to obscure the nuclei, but fading off to almost no pigment at ora serrata; pigment everywhere light or yellowish brown. A few cells of the hexagonal retinal epithelium on choroid, near optic disc, contain a little finely granular yellow brown pigment, much less than on iris or ciliary body; some of these slightly pigmented cells are much swollen (? pathological, or due to mode of preservation = Zenker's fluid, three-quarters of an hour after death by hydrocyanic acid in warm weather).

XI. 9 ♂ *Fe*: albino, grew to be a handsome dog. Coat quite skewbald from birth and remained so permanently, the colour of the coloured areas changing as he grew up from that of Fum (XI. 11) to about the present (August 1911) or adult colour of XI. 10 (Fo). The white areas were, and remained, pure white and are well shown in photographs taken in May when between 3 and 4 months old (Plate ϕ (19), (20) and (23)). He afterwards went to a new owner and when about a year old was run over by a van and had to be destroyed. Plate ηη (2) shows schematically the arrangement of the white and coloured areas in November 1910, age nearly 6 months.

XI. 10 ♂ *Fo I*: albino, has become a handsome dog and filled out to be as heavy as his sire Jack. Very soon after birth he was noted as coloured all over, so far as could be readily seen, like the dark parts of Fe (XI. 9) but a rather lighter shade. Plate ϕ (20) shows him when between 3 and 4 months old and Plate ϕ (24) and (26) his appearance, August 26, 1911, when aged rather over a year and a half. The light blaze at middle of scalp in the puppy portrait (20) does not show in another photograph taken at the same time where the light falls differently, and as there was in August 1911 not the slightest lightening of colour there the appearance in (20) must be put down mainly if not entirely to the illumination; although in the absence of any written note when (20) was taken the point remains unproved. At present he has a small white spot on each cheek, a larger one on front of each shoulder, a lozenge or oval patch on breast over sternum, a long pointed triangle on under surface of tail, all four limbs from carpus or tarsus to toes are white both back and front whilst a broad band of white is continued on back of foreleg as far as elbow and on front of hind leg as far as knee (patella). These white parts are precisely symmetrical and the white is pure white. The pale yellowish brown or light fawn of the coloured portions is considerably darker on the head than elsewhere especially on forehead between the eyes and at the strongly pronounced "spectacle mark." Plate ηη (1) shows schematically the distribution.

XI. 11 ♂ *Fum*: albino, puny and small, dying of inanition aged 35 days, killed with chloroform. Coat a decided and uniform brown everywhere except on chest and under aspect of neck, the entire surface of feet and tarsal and carpal part of legs and inner aspect of legs up and about elbows and patellae all of which parts were pure white; no white on any dorsal part. No darker dorsal streak. No "spectacle marks." Microscopical sections of the eyes show the usual conditions; mesoblastic tissues of iris, ciliary body and choroid quite devoid of pigment; retinal epiblastic layer (pigment epithelium) of iris lightly pigmented, nuclei being easily seen, corresponding part (outer layer) on ciliary body more pigment, but not enough to obscure nuclei. Pigment yellowish brown. Hexagonal retinal epithelium on choroid from ora serrata backward shows no trace of pigment. Anterior chamber shallow and filled by a granular mass containing staining nuclei. Skin kept almost entire and reproduced by photography as Plate ψ (right), where the index number X. 12 is given in error. It must be compared with the skin of a complete albino on the same plate to left.

XI. 7—11 Samples of the hair of this litter were examined by E. Y. Thompson, and some doubt having arisen as to possible pigment granules, she consulted Dr O'Donoghue, who took the view that the "foreign bodies" referred to below are not pigment granules.

XI. 7 ♀ The hairs show no diffused pigment and no granules. By "diffused" pigment is meant, unless otherwise stated, throughout these hair investigations diffused coloration distinguishable under a No. 6 Leitz objective.

XI. 8 ♀ *Fi*: in hairs from the back, there was scarcely any diffused pigment under $\frac{1}{12}$th and no granules. In

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hairs from the tail, which appear yellow macroscopically, there was no diffused pigment and no granules microscopically. But there were some very decided foreign bodies which are pigmented a yellow green; these foreign bodies do not seem to be granules and they are not broken down core; but they cannot be ignored as they are just the difference between Fi's hairs from the back and from the tail and the tail is much more coloured than the back. These "foreign bodies" also appear in the albino puppy, XII. 8, and in Fi's litter-sibling Fum. In hairs from the "spectacle mark" of Fi, no granules were found, there was a pinkish yellow colouring which was more like a stain than diffused pigment.

XI. 10 ♂ *Fo I*: the hair of this dog was examined as a puppy. In hair from the "armpit" there was a slight creamy diffused pigment, vacuoles but no granules to be seen. In hair from the front of neck, white hairs, there was no diffused pigment, no granules, but vacuoles. Another sample of Fo's hair was obtained on June 28, 1911, there was practically only very pale diffused pigment, but some granules (β) were found. The specimen sent was macroscopically yellow or fawn. At the same time a specimen of hair from the back of the mother Jill, X. 10, was examined. It was taken on Sept. 30, 1911, when she was still suckling pups born on August 4, and macroscopically the shade was decidedly darker than normal. The hairs were macroscopically of two kinds white and yellow. In the white hairs there was no diffused pigment and there were no granules. In the yellow hairs there was very, very pale diffused pigment, there were no granules, but "foreign bodies," such as had been found in the hairs of Fi and Fum, were discovered.

It seems clear that while it is impossible to detect in the hair of Jill any certain granular pigmentation, and while this holds for the great bulk of the albinos bred under these experiments, yet the mating albino × albino may lead to cases in which actual granules do certainly occur as in the case of Fo, or to cases in which it is almost impossible to be certain whether very small bodies occurring are granules or not; further certain "foreign bodies" may occur in these albinotic hairs the nature of which is not very clear. In general it would seem that pigment granules may be so small and sparse, that it is difficult to be dogmatic at all about their existence—and thus any rigid line between the albinotic and non-albinotic becomes idle. It is certain that macroscopically such a skin as that of Fum, or the skewbald coats of Fe and Fo, would never be described as albinotic. The appearance of these decidedly coloured albinos seems restricted to the offspring of Jack and Jill; the offspring of Jack and Tong or Jack and Wee Tong have not shown these initial skewbald or brown hair stages in the same marked manner.

XI. 11 ♂ *Fum*: there was very pale straw-coloured diffused pigment and only a few very indistinct rather doubtful granules in Fum's hairs, but groups of the above mentioned "foreign bodies" occurred. The white hairs are absolutely free from these "foreign bodies[1]."

XI. 12 ♂ *Unnamed*: albino, died at birth. The eyes and skin of nose fixed in 10 °/$_{\circ}$ formaline and examined microscopically. *Eyes*: no stroma pigment anywhere, but a very few pigmented (probably clump) cells in sphincter and some other parts of iris. Epiblastic (retinal) stratum on iris shows its two layers of cells very plainly; anterior layer very lightly pigmented, more towards root of iris than towards pupillary border; posterior layer contains much less pigment than anterior but does contain a little. On ciliary body outer layer of epiblastic stratum especially on ciliary process shows considerably more pigment than on iris, but nuclei not hidden by it. Pigment decidedly more dusky or blackish in hue than in XI. 7, 8, and 11 and VII. 17 (Tong I), though as much spaced as in them. Hexagonal retinal epithelium on choroid from ora serrata to equator shows some faintly pigmented granules in a few of the cells; further back than equator no trace of pigment in them. *Skin of nose*: sections taken across the short axis of the band, where the spectacle marks would be if present, show (under powers up to $\frac{1}{12}$th immersion) a number of hairs cut more or less longitudinally within their follicles and others above the free surface. Some, but not all of the intrafollicular hairs and many of the supradermal ones show pigmentation of two kinds: (*a*) a faint yellow, diffused colour like a stain of the entire substance of the hair, (*b*) elongated dark bodies lying parallel to hair axis of brown or yellowish brown colour[2] and composed of closely packed fine granules; they lie in the perimedullary layers of the shaft; the granules forming these compound dark bodies appear (to E. N.) to be coloured, but here and there a "dark body" appears to be empty. There are also fine scattered separate granules in many of the supradermal hairs. None of the granules or dark bodies are coloured by the eosin stain as in XII. 8 (see p. 504). There is no trace of pigment either in epidermis or rete.

XI. 13 ♀ *Patty*: albino, litter sibling of XI. 12 in the third litter of Jack and Jill. When 2 days old Patty was particoloured light brown or fawn and pure white in large, sharply defined symmetrical areas like Fe (XI. 9) and, as in Fe, distal half of tail white, the brown or fawn rather darker near root of tail than elsewhere. A photograph taken in November, 1910 (age 3 months) shows a definite "spectacle mark." In

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[1] For comparative purposes the hairs of two retriever puppies, one brown, one black, about four weeks old were examined. The former had hair with light yellow brown diffused pigment and plentiful granules (ϵ); the latter very dark brown diffused pigment and the hair densely packed with granules (ζ).

[2] These seem to be identical with the "foreign bodies" of E. Y. Thompson. It does not seem on further examination of her slides possible to assert the existence of definite pigment granules in these bodies for her cases.

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January, 1911, when about 5 months old, her coat began to go lighter and before long she was distinctly whiter on the coloured parts than either of her parents, having previously been much darker. Plate *v* (12) shows her in August, 1911, just 12 months old. The "spectacle mark" is still present but very faint and its area small. Weight, October 13, 1911, just under 10 lbs.; a quiet, good tempered, very lovable dog. Specimens of the hair from Patty's tail were examined at 23 days and at 4 months, in neither case were pigment granules found.

XI. 14—17 3 ♂, 1 ♀ Albinos, fourth litter of Jack and Jill, born August 4, 1911.

XI. 14 ♂ *Fo II*: albino, white coat. This is the only one of this litter to survive; it did well and was given away. As a puppy it presented the skewbald appearance, being nearly white all over except on face, ears and distal two-thirds of tail, which were light buff-brown, not so dark, however, as XI. 15. There was a tuft of pure white over the withers. Eyes albinotic. Weight $3\frac{3}{4}$ lbs. at 10 weeks (Oct. 13, 1911).

XI. 15 ♂ *Lo*: albinotic eyes, but brown coat[1] of dull shade and tint, much like that of Fum, XI. 11; pure white on feet, over knee of hind leg (patella), under surface of tail and a large patch on breast, in these respects like Fo I (XI. 10), with no white on forehead. Did well for 8 weeks; found dead in yard October 1st, the night being the first cold night of the season; he had probably got pushed out of the lair; examination showed all organs macroscopically healthy. Marked ● in pedigree to denote this coloration and skewbald condition as a puppy.

XI. 16 ♂ *Unnamed*: albino, could not suck, but kept constantly moving head as if trying to find teat; palate and nostrils normal; died at 21 days of inanition in spite of careful attempts to rear it. Pupils very pink, coat uniformly almost quite white. Skin from centre of back and both eyes kept in 10 $^\circ/_\circ$ formol. Microscopic sections of eye show entire absence of stroma pigment. There is scanty pigmentation, dark brown granules, in epiblastic layer of iris; decidedly more pigmentation of epiblastic layer (outer stratum) of ciliary body and a few widely scattered pigment granules in hexagonal layer on choroid about as far back as equator, but absolutely none seen further back. Skin of back shows hair almost white macroscopically; but microscopically the supradermal parts of the hairs show the same compound dark granule bodies and finely separate granules as are described under XI. 12 and XII. 8. The compound bodies appear brownish, but high magnification throws some doubt on the reality of this colour. Some of the hairs containing the largest number of the granule bodies show faint diffuse yellow staining.

XI. 17 ♀ *Unnamed*: albino, born dead; very large; apparently asphyxiated; was the last born of the litter; coat decidedly coloured. Eyes and piece of skin from middle of back placed in Zenker's fluid within 20 minutes of birth. Microscopical sections of the eye show total absence of mesoblastic pigment. Epiblastic layer of iris scantily pigmented and the pigment getting progressively less from the periphery towards pupil; perhaps, a few small "clump cells" close to sphincter muscle. Outer stratum of epiblastic layer of ciliary body as usual considerably more pigmented than that of iris. No pigment seen in hexagonal layer on choroid. Skin of back (darkest part of body): many of the supradermal hairs show in the cortex the usual two sorts of granule bodies and very small granules described under XI. 12 and XII. 8; none are eosin stained. The larger, or compound ones, are also found in a fair proportion of the intradermal parts of the hair shaft. These granule bodies appear to be brown even under $\frac{1}{12}$th oil objective. There is faint yellow diffuse pigmentation of shaft of a few hairs, chiefly those in which the granule bodies are most abundant, but the great majority of hairs show no perceptible diffuse colouring.

XI. 18 ♂ —?—: normal Pekinese son of Wee Wong, X. 12.

XI. 19 ♀ *Unnamed*: red tipped with black, white on breast and two spots of white on chin. Irides dark brown except for greyish at periphery; this grey ring represented by light brown ring in two other puppies seen at the same time. Seen at about 10 weeks; the property of Mrs Brabazon.

XI. 20—23 4 ⚲ s —?—: all coloured. Litter-siblings of albino XI. 24.

XI. 24 ♀ —?—: albino, nearly white coat, usual eye characters, bred by Mrs Perkins, seen by K. Pearson in 1910 and sold by its owner as a puppy.

XI. 25—29 3 ♀ s, 2 ♂ s Litter of five albinos—first albino litter of Tong I (VII. 17) by Jack (X. 9).

XI. 25 ♀ *Tong II*: albino; coat almost as white as in the mother, VII. 17. She was taken by Mrs Franklin and has had two all coloured litters by coloured dogs.

XI. 26 ♀ *Mairi bhan*: albino, the property of C. H. Usher.

XI. 27 ♂ *Ian ban*: albino, the property of C. H. Usher. Photographs of XI. 26 and 27 show the "spectacle mark" at about 8 months.

When aged $2\frac{1}{2}$, September, 1911, the coats of both X. 26 and 27 were almost uniform cream colour, but rather darker over spine and ears; the "spectacle marks" well indicated. Ian is somewhat darker than Mairi. Mairi bhan has had one litter of six albinos, XII. 17—22, to be discussed later. She then had apparently a miscarriage leading to sepsis, and the condition growing worse, she had ultimately to be killed. Post-mortem examination showed viscera of abdomen and of thorax, and the brain normal, the body was extremely emaciated. The whole uterine cavity including the cornua were distended with thin purulent fluid, and films of pus exhibited enormous numbers of streptococci. A full Report on the microscopic appearance of internal organs and eyes will be found in Appendix D (iii)—(iv) to this part of our monograph. Plate *υ* (5) shows Mairi bhan at 9 months and Plate *χ* (32) at 2½ years. Plate *υ* (16) and (18) give Ian ban at age 2½ years.

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[1] No diffused pigment and no granules were found in hairs tested by E. Y. Thompson.

XI. 28 ♀ *Ting II*: albino, now the property of Mrs Dew-Smith; her coat is decidedly whiter than her father's, X. 9, and much like that of her mother's, VII. 17. A photograph of August, 1909 (age about 7 months) shows the "spectacle mark" well developed. She has had three litters, one by her father the albino Jack, X. 9, all albinos (XII. 6—8), and two by the coloured dog Little Oo, XI. 40, all coloured, XII. 39—42, and XII. *a*—*c*.

XI. 29 ♂ *Unnamed*: albino, who died an hour after birth. The eyes and a piece of the skin of the nose of XI. 29 were fixed in Zenker's fluid and examined microscopically by Mr Coats; these eye sections are described p. 403 and figured Plate *ρ*, Fig. 4. A section of the skin of "spectacle mark" region given to E. Nettleship by Mr Coats, and examined October 15, 1911, shows in a very few of the hairs some of the elongated granule bodies described under XI. 12 (p. 501) and XII. 8 (p. 504); one hair shows them particularly well.

XI. 25—29 The eyes of the survivors of this litter were examined by focal illumination and with the ophthalmoscope when between 2 and 3 weeks old; sclerotic very translucent; irides, to reflected light, blue or slaty, the pupillary and peripheral being darker than the (thicker) central zone, moderately translucent to bright mirror illumination especially when sclerotic is exposed, the pupillary zone more translucent than any other part. Refraction measured approximately in one of the puppies with dilated pupil and paralysed accommodation showed a low degree of mixed astigmatism against the rule.

There was not in this first albino litter of Tong I any of the marked colour in the coat or skewbaldism of the Jack and Jill litters (XI. 5—18).

XI. 30 ♀ *Olga*: pure bred black Pomeranian bitch. Mated four times with the albino XI. 27, Ian ban, to produce the hybrid dog we have called a Pompek. The offspring XII. 23—30 and 38 will be described below. Olga is figured on Plate *χ* (27) and Plate *τ* (5), the latter portrait has the special object of showing the shape of her muzzle. She is a black Pomeranian of the smaller type, and is a pedigree dog. It seems unnecessary to reproduce her pedigree here. Her registered name is "Deeside Duchess." Both her parents are black, her four grandparents are black, her eight great grandparents are black, her 16 great great grandparents are all black. Of her 32 great great great grandparents 28 were black, two are known to have been brown, and two are unknown as to colour, *i.e.* the dam and sire of the imported black dog Champion King Pippin. She has therefore almost as pure a black ancestry as it is possible to obtain. She is the property of C. H. Usher.

XI. 31—33 2♂s, 1♀ Last litter of Tong I (VII. 17), sire Jack, X. 9, all albinos and showing when born only slight greyness of coat without piebald markings. This litter was born August 1, 1909. They are large dogs all strong and healthy and whiter than their sire taking after their dam in this respect, but less typically Pekinese than she was.

XI. 31 ♂ *Wee Ling*: albino. K. Pearson wrote as follows of this dog in September, 1911. A heavy large dog for a Pekinese, and the largest Dondo I have seen; he was originally the smallest of the litter. Affectionate to his owner's family, but very fond of his own way; nearly always polite to the most irritating of female dogs and ready to play with males, but on the least sign of bad temper will fly at a dog double his size and generally be victorious. Hates strangers, especially men, and on this account has to be largely kept on the lead, also because no amount of beating will prevent him chasing cattle, sheep, or game. Good at all dogs' tricks, begging, dying and running after balls. Sight much worse than that of his mother or sister. Plate *υ* (2) shows the photophobia exhibited in full sunlight. He will run against a post, or past his favourite victim, if he does not scent him, and misses a thrown stick or ball, which his sister Wee Tong sees at once. Scent very keen indeed and he will readily follow vermin or game by scent. Deafness not real, but only put on, when he is told to do something he does not care to do. "Spectacle mark" very pronounced, but varies in size according to amount out of doors in sunlight. Very little yellow or cream in coat. Portraits, Plate *υ* (2), (3) and (6). Like his mother Tong I rather liable to digestive upsets, due to getting damp or to wet feet, but no rain keeps him indoors, if there is a suggestion of a walk. Bred by K. Pearson and given as a puppy to Sir Francis Galton; eventually returning to his breeder.

XI. 32 ♂ *Wee Choo*: albino. The biggest of the litter as a puppy but when last seen much smaller than XI. 31. Very white; believed to be fairly healthy, but has had a growth removed from his leg by present owner. Given away as a 4 month old puppy and not recently seen.

XI. 33 ♀ *Wee Tong*: albino. Affectionate, but rather characterless dog, much smaller than Wee Ling, and about the same degree of whiteness. Very little yellow or cream tint, and when shut up with puppies loses all "spectacle mark" although usually she has a good deal. Very nervous like her mother Tong I, but

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when frightened may turn and attack what has frightened her. Distinctly pugnacious. Will not readily go out in the rain or follow if alone, but if another dog goes also is ready for a walk. Has an intense dislike for cats, whom she in no way fears; dislikes strangers, and is always irate if she hears an unknown footstep, or if a stranger is in the house. A most excellent mother, but a rather delicate dog, liable to cold or loss of appetite. Scent is as good as in Tong I or Wee Ling, but not so engrossing a sense as with latter. Sight is not very good and she shows photophobia: see Plate *v* (2). She begs, carries ball or stick, etc., but not so teachable as Wee Ling. Portraits, Plate *v* (2) and (4).

XI. 34—37 1 ♀, 3 ⚲ s Litter of four. Names unknown. One albino bitch and three unsexed reds with black muzzles, born December, 1908. The albino was cream coloured. Sire O-lo-Peen, X. 17, and dam Whitey, X. 21, an albino. O-lo-Peen also got an albino, XI. 41, by X. 20*a*.

XI. 38 ♂ —?—: a red dog, mated with albino, Tong II (XI. 25), and giving the litter of coloured dogs, XI. 34—37.

XI. 39 ♀ *Dido*: pure black Pomeranian bitch, the property of C. H. Usher. She has more brown ancestry than Olga, XI. 30. Both her parents are black; she has 3 black grandparents and 1 brown. Of her 8 great grandparents 7 are black and 1 is of unknown colour. Of her 16 great great grandparents 11 are black, 2 brown and 3 of unrecorded colour. Of her 32 great great great grandparents 16 are black, 4 brown, and 12 of unrecorded colour. Thus she has certainly more brown than Olga in her ancestry. At present she has had 3 puppies, 1 by the albino Ian ban, XI. 27, and 2 by the albino Donald ban, XII. 18; they are all three of the usual black Pompek type: see XII. 33 and XII. 43—44 below.

XI. 40 ♂ *Little Oo*: general coat light reddish-brown, dark mask, eye and tail. Born about 1909—10; owner Mrs Dew-Smith.

XI. 41 ♂ Albino dog the offspring of Palace Mi-Mei (X. 20*a*) by O-lo-Peen (X. 17): see footnote p. 462. An examination (see V. 24 *a*) was made of Roma's hair to ascertain how nearly she possessed albinism of the coat. But Mi-Mei may quite well have inherited latent albinism from her father Goodwood Lo.

XI. 42 ♂ *Dugald ban*: albino = XII. 17.

XII. 1—5 4 ♂s, 1 ♀ Litter of five, two males with nystagmus, two with steady eyes, one female died very young. All five coloured with black noses and dark irides: see above, p. 475.

XII. 6—8 2 ♀s, 1 ♂ Litter of three, all albinos; born October 28, 1909, sire Jack (X. 9), dam Ting II (XI. 28), both themselves albinos.

XII. 6 ♀ *Wee Wee*: albino; grew up and is healthy, with usual albino characters, moderate or pale cream colour.

XII. 7 ♀ *Wei Wei*: albino; grew up and is healthy, of the same characteristics as her sister XII. 6. Specimen of her hair was examined October 26, 1911. There was no diffused pigment; "foreign bodies" were present and a very few scattered granules.

XII. 8 ♂ *Unnamed*: albino. Died December 18, 1909, aged $7\frac{1}{2}$ weeks. Eyes and skin of nose fixed in 10 $^\circ/_\circ$ formaline, and microscopically examined. Eyes: no trace of pigment in mesoblastic tissues of iris, ciliary body or choroid. Epiblastic layers on iris lightly pigmented, peripheral part of posterior layer (near root of iris) contains much less than the anterior, and the more central part of posterior layer (towards pupil). More pigment in ciliary body epiblast than in iris. Hexagonal retinal epithelium on choroid shows no trace of pigment. The pigment in this eye is richer brown (less yellow) than in most of the other specimens. Skin of nose, across short axis of spectacle mark belt; no trace of pigmentation in epidermis, rete, or true skin; hairs, some cut transversely, others more or less longitudinally, some intradermal, others well above skin surface; many of them show a greater or less degree of pale diffused yellowish coloration as in XI. 12 (see p. 501 above), and all contain bodies that look under low powers like elongated dark granules lying chiefly in perimedullary parts, seldom quite in medulla, and always parallel to length of hair. In the intradermal portions of the hairs many of these "granules" are coloured (red) by the eosin stain, and in some few places in this situation the same hair shows unstained and red stained bodies side by side. But in the supradermal parts of the hairs, none of these bodies are stained; all are composed of fine closely packed granules, some of which are, or appear to be, brown; others either dark or colourless according to focussing. Possibly the brown appearance may be an effect of the diffuse yellow colouring (?). In addition to these relatively large bodies are large numbers of very fine separate granules (? spaces) resembling the constituent granules of the larger bodies, and these follow the same rule as to eosin staining. Many of the larger or compound granules and most if not all the minute separate granules are resolved by $\frac{1}{12}$th immersion into highly refracting colourless bodies,—either black or colourless—but some appear to me (E. N.) to be brown as in XI. 12. The appearances as a whole suggest elongated spaces in the cortical layers of the hair filled with (? fatty) granules, which are colourless in some cases, and brown in others; and it is possible that the larger or compound ones represent dead and degenerated nuclei of the hair cells[1].

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[1] [Examining the hairs of this puppy independently E. Y. Thompson reported no granules, but "foreign bodies." There is thus no doubt that the "foreign bodies" of Dr O'Donoghue and E. Y. Thompson are the "elongated spaces" of Nettleship. K. P.]

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XII. 9—13 2 ♂s, 2 ♀s, 1 ⚲ Litter of five normal puppies born January 17, 1910 to Tong II (XI. 25), albino dam, and Minoru (X. 1), a red dog without any white. All five are either red or chinchilla with a little white on toes. The unsexed dog died a week old.

XII. 14 ♂ *Yang ren*: albino, born August 2, 1911. Dam Wee Tong (XI. 33) albino, and sire Jack (X. 9) albino. He possesses the usual albino characteristics of the whiter, or more albinotic type. He is a large dog and was given by the breeder, K. Pearson, to Mrs Renton of Arkinworth Hall. He is a favourite and good at tricks. Two investigations of Yang ren's hair have been made. First, hair of tail, on Sept. 15, 1911, which then appeared his darkest part. Some of the hairs showed no diffused pigment and no granules; others very pale diffused pigment and some granules (β, on our scale). The second examination was made two months later November 12, 1911. No diffused pigment was now found and no granules, but there were groups of very marked and fairly numerous "foreign bodies" in the perimedullary parts. Dr O'Donoghue kindly examined these later hairs, and confirmed the view that there was absence of true granular pigmentation.

XII. 15 ♀ *Tin lo*, albino, litter sister to Yang ren, XII. 14, with very like characters. A well built little dog, with good Pekinese features. She died of distemper at about five months old. A report on her internal organs—all devoid of pigment—by Dr Low, and on her eyes by C. H. Usher, will be found in the Appendix D (i) and (ii) to this section of our monograph. Specimens of Tinlo's hair were taken on September 15 and November 12, 1911. Some of the hairs from the tail of the earlier date had no diffused pigment and no granules; others had a pale brown diffused pigment and a decided number of granules (γ of our scale). A large majority of the hairs examined on the second occasion were absolutely clear, without diffused pigment or granules. But some of the yellowish hairs contained pale yellow diffused pigment, and a considerable quantity of the "foreign bodies," but no granules. Some of the hairs are particoloured, white and yellowish, these show "foreign bodies" in the yellowish part, but are absolutely clear in the white part.

From the accounts of the hair of XII. 8, 14, 15 given above, it would seem as if in the extremely young dogs there was some attempt to form pigment granules, but that changes took place with age and that as a rule no granules appear in the adult albino dog. On the other hand an exception may occur to this rule, as in the case of the albino bitch Wei Wei (XII. 7), where a very few scattered granules were found. The bearing of all this on the statement we have frequently had to make that albinism in the dog as in man is a graded character will be obvious.

XII. 16 ♀ —?—: red with black mask, black nose and dark eyes. Born May, 1910, daughter of XI. 18. Has nystagmus. She is a granddaughter of Wee Wong, litter brother of the albinos Jack and Jill. Not seen, but reported to E. N. by the lady who owned the dogs, X. 13 and XI. 19, both of whom have nystagmus and are of the same stock. It is clear that all our five cases of nystagmus are descended from Manchu Tao Tai and Manchu Wei Wei (VIII. 6 and 10), through the brothers Wong Sing of Braywick (IX. 4) and Chu-êrh of Alderbourne (IX. 6).

XII. 16 *a* ♀ *Beenie*: albino. Beenie is granddaughter of Wee Wong the normal litter brother of Jack and Jill. She is of the usual cream coat, "spectacle mark" not well marked; hair particularly long on all feet projecting beyond the toes. Pupil red reflex seen, iris usual greyish colour; no apparent photophobia.

XII. 16*b* ♂ *Prince*: pure-bred black Pomeranian. He is the son of Janos and Deeside Duchess (our Olga, XI. 30). Thus his parents, his grandparents, all his great grandparents, all his great, great grandparents are black, and of his 32 great, great, great grandparents 28 are black, one brown and three unrecorded colour. Although more black in ancestry than either Olga or Dido, he has when crossed with an albino Pekinese failed to give the usual Pompek and produced two chocolate dogs.

XII. 17—22, 6 ♂s Litter of six male albinos, offspring of C. H. Usher's bitch Mairi bhan, by his dog Ian ban, both parents being albinos; born December 12, 1909. XII. 21 and 22 died two or three days after birth; were much smaller than the others, both nearly but not quite white, the larger one being rather more coloured than the other, especially on head and ears, no "spectacle mark" in either. XII. 20 was similar to XII. 21 and 22 and died young. The eyes of XII. 21 and 22 were examined microscopically by C. H. Usher, who found that they closely resembled in distribution and amount of pigment the eyes of XIII. 1—5 and 8—10.

XII. 17 ♂ *Dugald ban*: albino. When 10 months old noted by C. H. Usher as having cream-coloured coat, darker on top of head and posterior part of back. "Spectacle mark" well developed; hair of neck curly. In September, 1911, Dugald ban was a big dog, weighing 16 lbs., bigger than his father and coat somewhat darker.

XII. 18 ♂ *Donald ban* (or "Idiot": see Plate *v* (8), where erroneously called XII. 17): albino; when 4½ months old, coat pale cream, lighter than his brothers but distribution similar; fully developed "spectacle mark." At 1¾ years (August, 1911) the colour as before, dorsum of tail and of feet darker than other parts, belly white, cream on chest; "spectacle mark" well developed. Donald ban is now said to be of average intelligence.

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XII. 19 ♂ *Hamish ban* (see Plate *v* (13), where erroneously called XII. 13): albino. At 4½ months old resembled his brother Dugald at 10 months in the depth of cream colour and development of "spectacle mark." At 1¾ years (August, 1911) he resembled Donald, neither lighter nor darker; and had only feebly emphasised "spectacle mark."

XII. 23 ♂ *Donald dhu*: perfectly black "Pompek," except for two or three quite white hairs on chest, noted by C. H. Usher August 6, 1911. Donald dhu and his litter-brother Dugald dhu were bred by C. H. Usher as a result of the first mating of the albino sire Ian ban (XI. 27) and the black Pomeranian dam Olga (XI. 30). They were born September 12, 1910. There is no red tinge in the coat. Head appears at first sight like Pekinese, but on actual measurement was found both as to nose and muzzle intermediate. Irides dark brown, pupils black, nose black; tail curled over back. Lower jaw somewhat underhung (projecting), causing teeth to show: see photographs Plate χ (32) and (33). Donald dhu is a very affectionate dog, but more timid than the usual Pekinese. He has also the sharp, somewhat irritating bark of the Pomeranian. Forelegs straight. Transferred to K. Pearson.

XII. 24 ♂ *Dugald dhu*: whole black "Pompek," except that there are about a dozen perfectly white hairs on a small area at upper part of chest. No red tinge in coat. In colour and conformation identical with his brother Donald dhu. See photograph, Plate χ (34).

XII. 23 and 24, as first Pompeks bred, led us to believe that black dominated white, and that the Pekinese muzzle was also dominant, rules, however, not substantiated now that we have found (i) that a majority of Pompeks have white shirt fronts, a feature not known in the Pomeranian ancestry, (ii) that Pompeks can be chocolate as well as black, a result we are told that arises when black and white Pomeranians are crossed and (iii) that muzzles must be measured to be classed.

XII. 25—26, 1 ♂, 1 ♀ Second litter of Pompeks by same sire and dam, born March 21, 1911. In this case both dogs have white shirt fronts, or inheritance is particulate.

XII. 25 ♂ *Ian dhu*: Pompek, faint rusty black[1], the reddish tinge, very marked in comparison with the coat of his sister; some white hair on under lip and tips of paws, and a considerable white patch on chest; ears more of Pekinese type; iris brown, pupil black, nose black, snout blunt, lower jaw projects a little but not enough to show teeth; forelegs straight. Portraits as puppy on Plate χ (29) and (36); also at rather later date on same plate (28).

XII. 26 ♀ *Mairi dhu*: Pompek, coat quite black except for white on chest; no white on foot, no reddish tinge anywhere; iris brown, pupil black, nose black; ears more Pekinese, but head perhaps more like Pomeranian than other three; lower jaw projects, exposing some teeth. Described in April, 1911 and again at end of September 1911 (aged 6 months); conditions same at each date. For portrait, see Plate χ (30).

XII. 27—30, 2 ♂s, 2 ♀s Third litter of Olga by Ian ban, born September 20, 1911. The two males died at birth. Both were black with a few white hairs on chest, but none visible on feet; muzzle blunt. The female, XII. 29, also died, she was black all over except for white on chest.

XII. 30 ♀ *Buna dhu*: Pompek, the only survivor of Olga's third litter. She has white on the chest: see photograph, Plate χ (35), and some white on the two middle toes of R. hindfoot and on the three inner toes of L. hindfoot.

XII. 31, 32, 2 ♀s Litter of two, both females, born June 15th, 1911; both dogs are brown, the dam being the albino, Ting II (XI. 28), and the sire, the light red dog with black mask, Little Oo (XI. 40).

XII. 33 ♀ *Yfa dhu*: Pompek, black with white patch on chest. Offspring of Ian ban (XI. 27) and the pure black Pomeranian Dido (XI. 30). Born May 8, 1911. Described August 9, 1911. Coat black with a reddish tinge, iris brown, nose black. Head in appearance more Pekinese, drooping ears, lower jaw projects a little. Forelegs straight. For portrait as puppy, see Plate χ (31). She was the sole puppy in litter.

XII. 34—37, 4 ⚲s Litter of four red puppies, born at end of 1910 or early in 1911, unsexed; all red; the result of mating Tong II (XI. 25) with a red dog (XI. 38), whose name, owing to death of owner, cannot now be ascertained.

XII. 38 ♂ *Fraoch dhu*: Pompek, sole puppy of Olga, black Pomeranian (XI. 30), in her fourth litter by the albino Ian ban (XI. 27). Black coat with an unusually large white shirt front, reaching from chin over chest to belly: see photograph, Plate ζζ (3).

XII. 39—42, 2 ♂s, 2 ♀s Litter of four normally coloured dogs from the albino Ting II (XI. 28) and Little Oo (XI. 40). This litter was born December 25, 1911. Ting II's *first* litter was by the albino Jack (X. 9), and consisted of three albinos (XII. 6—8). Her *second* litter had Little Oo for sire; it consisted of two females: (i) XII. *d*, *Mee Mo*: coat dark red brindle, black on tail, shoulders, back and ears, chest grey (black and white mixed), feet white; black mask, pinkish black nose and dark brown eyes, and

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[1] This reddish or rusty tinge is commonly noted in Pomeranian puppies, which afterwards become quite black. K. Pearson noted it in Cilis XIII. 20, who has now a good black coat.

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(ii) XII. *e*, *Maud*: light red coat with darker saddle, black mask, black nose and dark brown eyes. The above XII. 39—42 is accordingly the *third* litter of Ting II and the second she has had by Little Oo.

XII. 39 ♀ —?—: dark brindle, dead.

XII. 40 ♂ *Wang II*: coat brindle, black mask and nose, dark brown eyes.

XII. 41 ♀ *Tong III*: coat dark red and brindle with black on tail, back and shoulders, black mask and nose and dark brown eyes.

XII. 42 ♂ *Jacob*: coat fawn, dusted black, underneath white with black patches; black mask, pinkish black nose and dark brown eyes.

XII. *a*, *b*, *c*, 3 ♀s Fourth litter of the albino, Ting II, her third by Little Oo. Born Jan. 21, 1913. One is biscuit colour like Little Oo, the other two dark red brindle; all three have black masks and noses, and no conspicuous white. XII. *d*—*e*: see above under XII. 39—42.

XII. 43—44, 2 ♀s Second litter of Dido, XI. 39, black Pomeranian, this time by Donald ban (XII. 18), the albino. Both born and both died October 1, 1912. Both could thus only be described at birth.

XII. 43 ♀ *Unnamed*: head all black, longish nose, neck, body and back black. Chest white from axilla to axilla and down to beyond xiphoid; broad at episternal notch, pointed below; throat black, belly pink, bare. Forelegs, R. and L. black; forefeet, R. black, L. white, all below wrist; hindlegs and hindfeet R. and L. black; tail black; mouth mucous membrane pink—no black; coat smooth and glossy.

XII. 44 ♀ *Unnamed*: head all black, longish nose, neck, body and back black. Chest white, episternal notch to xiphoid white, does not extend more than half way from mid-line to axillae; throat black, belly pink, bare. Forelegs, forefeet, hindlegs, hindfeet and tail all black, coat smooth. Mouth mucous membrane pink. Malformation of orbits: R. very much diminished orbit and no trace of eyeball (macroscopically examined); L. orbit larger, but also abnormally small, no eyeball, merely some gelatinous pigmented tissue. Hairs from XII. 43 and 44 showed in both cases dark brown diffused pigment and very plentiful granules (ϵ).

XIII. *a*—*e*, 4 ♂s, 1 ♀ First litter of Beenie (XII. 16*a*), albino bitch, and Prince, pure black Pomeranian (XII. 16*b*). The first three puppies were typical black white-fronted Pompeks, the fourth and fifth chocolate coated. Born February 5, 1913. The descriptions are of the dogs as new-born puppies or a fortnight old.

XIII. *a* ♂ —?—: usual type of Pompek. Coat uniformly black; hair smooth, head and ears black; long white patch on chest. The four toes on both forefeet are white; a few white hairs at root of claws of middle toes of right hindfoot; left hindfoot quite black; square muzzle; mucous membrane of nose black; iris dark brown.

XIII. *b* ♂ —?—: usual type of Pompek. Coat uniformly black and smooth, with large long white patch on chest; all toes of right forefoot are white; a few white hairs on two middle toes of left forefoot; a few white hairs at root of claws of middle toes of left hindfoot; square muzzle; mucous membrane of nose black; iris dark brown.

XIII. *c* ♀ *Unnamed*: died when 10 days old. Usual type of Pompek. Coat black, silky, straight-haired; small patch of white on chest; forepaws black; hindpaws, left black, right black except a few white hairs at root of claws of two middle toes; iris dark, membrana nictitans pigmented; eyes had not opened.

XIII. *d* ♂ *Unnamed*: died February 17, 1913, 12 days old. Unusual type of Pompek. Coat uniform chocolate colour; hair short and smooth; white patch on chest, 1″ in length, $\frac{3}{8}''$ in breadth (the length of pup from forehead to tip of tail was $7\frac{5}{8}''$). Paws and toes chocolate, except right forepaw, which has white hairs at root of two middle claws; mucous membrane of nose chocolate colour; eyes unopened, iris grey, much lighter than that of pup, XIII. *c*; marked red reflex in pupils; membrana nictitans has brown pigment at free edge, but not so much as has membrana nictitans of XIII. *c*. An eye of XIII. *d* and one of XIII. *c* were opened and examined with a lens; there was a marked difference in the pigmentation of the fundus. In the black pup XIII. *c* the fundus is dark, whilst in the chocolate pup it has only a faint brown tinge. This will account for the great translucency and redness of pupil noted in the chocolate pup's excised eyes. Ciliary body very dark in both pups' eyes. Iris, posterior part dark in each, but surface of black pup's iris is darker than that of chocolate pup. Microscopic examination of the hair shows yellow brown diffused pigment with plenty (δ) of granules in most of the hairs, but chest hairs with no granules.

It will be seen that the albinotic characters have not been wholly dominated in this chocolate puppy by the pigment of the black Pomeranian parent. Besides the white shirt front, which it shares with other Pompeks, there is the reduced pigmentation of the coat and nose, and, what is of more significance, the lessened pigmentation of the eye. It is noteworthy that the sire Prince has a purer black ancestry than either Olga or Dido.

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XIII. *e* ♂ —?— : unusual type of Pompek. Coat smooth chocolate colour; head, ears, legs and paws are of same colour, white strip on chest; mucous membrane of nose chocolate colour; square jaw; iris pale brown. This pup when examined March 26, when 7 weeks old, had a distinctly paler iris than in the case of the living black pups. Examined with the ophthalmoscope, and compared with XIII. *a*: (1) the fundus of the chocolate pup was obviously paler than that of the black pup, but it was not nearly so deficient in pigment as the fundus of an albino Pekinese and probably could not be termed albinotic. Media clear in both animals. (2) Iris of chocolate pup brown at pupillary zone and grey with small quantity of pigment in ciliary zone; black pup had dark brown iris. (3) No pigment visible at limbus of cornea in chocolate pup; in black pup a black band of pigment is present at limbus. Hair examined April 16, 1913, microscopically; hairs have light yellow diffused pigment, and the granules vary from one or two (α) to plenty (δ); more hairs with no granules. Clearly has far less pigment than the usual black Pompek where the granules are densely packed (ζ).

XIII. *f*—*j* 2 ♂s, 3 ♀s This litter of five dogs, sire Prince XII. 16 *b* and dam Spook X. 20 were born March 29, 1913. They are all of the usual type of Pompek, black coat and white markings. There are no chocolate dogs, and there is no marked red tinge in coat, although it is doubtful if there is not a suspicion of red in XIII. *g* and *i*. All strong healthy pups, April 4, 1909. Two puppies only were left with Spook and the other three given to a foster-mother.

XIII. *f* ♀ Usual type of Pompek; black coat, large patch of white on chest, all toes on fore- and hindfeet white.

XIII. *g* ♂ Usual type of Pompek; black coat, moderate sized white chest patch, two middle toes of fore- and hindfeet white.

XIII. *h* ♀ Usual type of Pompek; killed (? by foster-mother) April 29, 1913; eyes black, black coat, moderate sized white patch on chest, two middle toes of forefeet, three inner toes of hindfeet, white, mucous membrane of nose black; pads of outer middle toes of hindfeet white, rest black.

XIII. *i* ♀ Usual type of Pompek; black coat, long white patch on chest, no white on feet.

XIII. *j* ♂ Usual type of Pompek; black coat, small white patch on chest, four toes on both forefeet white, no white on hindfeet.

XIII. *k*—*n* 1 ♂, 3 ♀s Litter of four; first litter from Pompek crossed with Dondo, the dam being Mairi dhu (XII. 26), a black Pompek with white shirt front, and the sire Dugald ban, XII. 17, pure bred Dondo. The offspring consisted of three typical Pompeks, black with white shirt front and one albino, of whom one female Pompek and the female albino have survived. For portraits of these two see Plate ζζ (4). Born July 26, 1912.

XIII. *k* ♂ *Unnamed*: typical Pompek, black with white shirt front. Died July 29, 1912. Coat jet black, except small white patch on chest, and a very few white hairs on under part of forefeet. Eye (macroscopic): fundus dark, ciliary body and iris dark.

XIII. *l* ♀ *Unnamed*: typical Pompek, black with white shirt front. Died August 5, 1912. Coat reddish black, except small white chest patch, no white elsewhere. Muzzle like Pekinese. Eye same as XIII. *k*.

XIII. *m* ♀ *Cabhagach dhu*: typical Pompek, coat black with white chest patch, no white elsewhere. Muzzle appears generally like Pekinese. See Plate ζζ (4).

XIII. *n* ♀ *Gartchonzie bhan*: albino. Coat creamy white (even nine days after birth) all over. Generally like the ordinary Pekinese albino. See Plate ζζ (4).

XIII. 1—5 3 ♂s, 2 ♀s Litter of five, all albinos, born December 20, 1910, being first litter of albino bitch Spook (X. 20), by Donald ban (XII. 18). Two were born dead and the other three were either killed or fatally injured by mother during first few weeks, although she nursed them well. Skins preserved.

XIII. 1 ♂ *Unnamed*: albino. Died January 23, 1911, aged 34 days, marked as biggest of the litter, as white as XIII. 2, except for very faintly marked dorsal streak[1]. Although the hair of face, ears and head generally is decidedly more coloured than the rest in all members of the litter, there is in the dried skins no intensification in any of them in the "spectacle mark" region.

XIII. 2 ♂ *Unnamed*: albino, died January 13, 1911, aged 24 days, as white generally as XIII. 4, but rather darker on the head, no dorsal streak.

XIII. 3 ♂ *Unnamed*: albino, still-born, very slight brown tinge of coat, as not unusual in these new-born albinos, rather more marked about head and mid-line of posterior part of back.

XIII. 4 ♀ *Unnamed*: albino, died of injuries, January 6, 1911, 17 days old. Whiter than XIII. 3, but probably not whiter than XIII. 5 would have been had it lived to the same age, no dorsal streak.

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[1] Such "dorsal streaks" are characteristic in the semi-albinotic dingo skins sent to K. Pearson and in the distribution of black hairs in the yellow red dogs like XIII. 22 and 23 when they are puppies.

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XIII. 5 ♀ *Unnamed*: albino, still-born, same as XIII. 4 or a trifle lighter, no darker dorsal streak.

The eyes of XIII. 1—5 were all examined microscopically by C. H. Usher, who reports that they all showed similar conditions as to pigmentation, there being no marked difference between one puppy and another in the amount of pigment and none at all in its distribution although the puppies varied in age from a few hours to rather more than a month. The conditions were: complete absence of stroma pigment in iris, ciliary body and choroid, retinal epithelium on iris and ciliary body lightly pigmented, the nuclei being easily visible in all cases; retinal epithelium on choroid absolutely pigmentless; towards the root of the iris only the anterior of the two layers of retinal epithelium is pigmented, the posterior or deeper layer shows no pigment, just as is normal for the corresponding layer lining ciliary body.

XIII. 6—10 2♂s, 3♀s Second litter of Spook (X. 20) by same sire Donald ban (XII. 18). All five albinos. Born July 16, 1911. XIII. 8, 9, 10 were puny and probably would have died, but one at least was killed by the mother, and the other two died apparently uninjured quite young. All five almost uniformly cream coloured, lighter on belly, no "spectacle mark" as puppies. The two males living at the end of 10 weeks show some more darkly coloured hairs in the "spectacle mark" region, the colour being intensified by moisture.

C. H. Usher reports that microscopical examination of the eyes of one of the dead female puppies showed conditions indistinguishable from those of XIII. 1—5 just described above, except that there was a small quantity of pigment in the retinal epithelium on the anterior part of the choroid.

XIII. 6 ♂ *Cyclops*: albino: see portrait as puppy Plate *v* (7). His right eye was excised for inflammation when a young puppy. Forelegs markedly knock-kneed. Coat colour usual creamy tint, coat very thick, "spectacle mark" small. Died March 18, 1913, after two days' illness; post-mortem showed all organs normal and indicated no cause of death. He then weighed $10\frac{1}{2}$ lbs., *i.e.* at 20 months old. Left iris of usual appearance; on removal translucency of the eye very marked, least at ciliary body. Right orbit, from which eye was removed when a puppy, was found to be very poorly developed. Skin, eye and internal organs preserved for fuller examination.

XIII. 7 ♂ *Wai*: albino. Coat usual cream colour and very thick. A strong dog. Forelegs bent like Pekinese. Iris of usual grey appearance; pupils show red reflex. A fine dog very like Cyclops.

XIII. *i*—*k* 3♀s Third litter of Spook (X. 20) and Donald ban (XII. 18). Born February 26, 1912. All three offspring albino bitches. Two died within 24 hours. Coats cream colour; mucous membranes of nose and mouth pink; no pigment on palate. Eyes: translucent grey iris; red pupils; eyeballs translucent throughout. The third pup was given to a foster-mother but died April 30, 1912. Coat woolly white. Irides blue grey, pupil red; eyes very translucent; on right cornea a large ulcer. It measured only $6\frac{1}{2}''$ from top of head to tip of tail and was very light in weight.

XIII. 11—15 5♀s Litter of five bitches the offspring of the Pompek bitch Mairi dhu (XII. 26) by the albino Pekinese Ian ban (XI. 27). The results are very noteworthy. Born January 24, 1912.

XIII. 11 ♀ *Piali dhu*: Pompek of the usual type, *i.e.* black coat with white shirt front. Her coat is all black—no white hairs on feet or toes—all excepting the well marked white patch on chest. Face in appearance rather Pekinese, flat and stumpy; dark iris, pupils black. Portrait on Plate ζζ (5).

XIII. 12 ♀ *Unnamed*: usual Pompek type with white patch on chest. Died February 12, when 16 days old. For photograph of skin, see Plate *aa* (right).

Length from tip of tail to snout 8″ when lying on side with neck stretched. No evidence of injury. It was thin and wasted looking.

Coat short, smooth, black straight hair all over with exception of (1) whitish hairs on chin; (2) some white on dorsum of three inner toes of right forepaw. None of the other paws have any white; (3) a white patch extending from a point half way down its neck on ventral aspect to a point opposite ensiform cartilage: the broadest part is $\frac{1}{2}''$ to $\frac{3}{4}''$ and is situated over anterior part of chest; the white patch gets narrower above and below this. The hairs are quite white on chest patch. Mucous membrane of muzzle black; ? some pigment on mucous membrane of mouth. Head short and stumpy of Pekinese type; no evidence of lower jaw projecting in front of upper jaw. Limbs: no deformities. Tail straight and black. Eyes are dark, microscopical examination shows well pigmented stroma and epiblastic layers of iris and ciliary body, also the choroid and retinal pigment layer are deeply pigmented; pigment present at limbus in the epithelium and in membrana nictitans at free edge.

XIII. 13 ♀ *Unnamed*: Piebald. Died January 26, 2 days old. Photograph of skin on Plate ω (right). *Head* short, stumpy, blunt snout; mucous membrane of nose is black, but part of right nostril is pink; no projection forwards of lower jaw; no pigment on palate. Limbs have no deformities. Tail straight. Coat is short, smooth and has straight hair. Colour: piebald, nearly equal parts of white and black. The white part is pure white and occupies the neck and passes forward to cover most of the crown of head and down to mucous membrane of nose. Both hindlegs are white, greater part of right side and greater part of forelegs, also part of left side and distal two-thirds of tail are white. The

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black parts[1] form a large black patch on each side of head which includes the ear and surrounds the eye; small spot of black in mid-line at back of crown; on left side of body are two large patches of black, the anterior one extends from spine, between scapulae, downwards to include the posterior part of humerus as far as its lower end; the posterior patch, separated by narrow white band from anterior patch, extends down to belly and is continuous across the back with a smaller patch on right side. The only other patch on right side is at posterior part of humerus and adjoining part of side. There are two other black patches, both in mid-line, one at root of tail, the other just anterior to this. Flexor aspects of neck, chest, belly and limbs are pinkish from scantiness of hair, though considerably less pink than the corresponding parts of the other dead pup, XIII. 15. This pup is larger and appreciably heavier than XIII. 15 who died on same day. Crown of head to tip of tail is 7½″ in this pup. There is a resemblance in the distribution of the dark areas in these two pups.

Eyes: on separating lids pupil appeared dark and iris brown. When held up to the light the excised eye had a marked red reflex. For microscopic examination: see Appendix D (v).

XIII. 14 ♀ *Unnamed*: Piebald. Died February 5, 12 days old. Photograph on Plate *αα* (left).

Coat short, smooth straight hair. It is piebald with about equal parts of black and white (pure white not cream colour). A large black area on back extends from ½″ behind shoulders backwards to buttocks and proximal third of tail, on right side it extends to belly, on left side it extends to belly only as a strip about 1″ in breadth; rest of left side is white. All four legs and distal two-thirds of tail are white; belly white; crown and face black including ears and eyelids except (1) white stripe in mid-line of crown, which is continued as very narrow strip to some white hairs on right upper lip; black patch on left side of neck that extends from spine downwards and forwards to under surface of neck, at one point this black patch nearly touches the black on head. Hair longer than in last two pups, *i.e.* first piebald and skew-bald. Length from crown of head to tip of tail = 8¼″. Tail straight. Limbs have no deformities. Head short, stumpy; snout blunt, in appearance Pekinese; mucous membrane of nose black; lower jaw not projecting; brown mottling on roof of mouth. Eyes after separating lids, cornea too opaque to see iris. For microscopical examination: see Appendix D (v).

XIII. 15 ♀ *Unnamed*: skewbald incomplete albino. Died January 26, two days old. The photograph of the skin is given on Plate *ω* (left). Photographs of this puppy and XIII. 13 will be found on Plate *τ* (4) and (5).

Head more like a Pekinese than a Pomeranian; snout blunt; mucous membrane of nose is pink; lower jaw does not project; no palate pigment. Limbs no deformities. Tail straight. Coat short, smooth, straight hair. It is partly creamy white like the ordinary albino Pekinese dogs and partly pale buff in about equal proportions. The white parts are the following: anterior third of back, including neck, crown of head in mid-line and down to tip of nose, left foreleg and lower part of left side; a white band passes from back to belly down right side; most of right hindleg; anterior part of left hindleg; a narrow strip of white across the back connects the white parts on hindlegs; distal third of tail. The buff parts[2] occupy the whole of the crown and face, with the exception of mid-line, they include ears and surround eyes; most of right foreleg, posterior two-thirds of back and sides, with exception of their lower parts, buttocks, proximal two-thirds of tail, posterior two-thirds of hindleg are buff coloured. Flexor aspects of neck, belly, chest and legs are pink from scantiness of hair. Crown of head to tip of tail measures 7¼″. Eyes macroscopically after separating the lids have red pupils; iris grey and translucent. The excised eyeball when held up to the light is exceedingly translucent, the least translucent part is the ciliary region. Eyes after hardening in 10 °/₀ formaline; one eye was opened antero-posteriorly without freezing. It resembles the ordinary albino Pekinese dog's eye; fundus looks pigmentless; ciliary body has a marked brown colour and posterior surface of iris is brown. No difference in appearance of fundus at and below tapetum. For microscopical examination: see Appendix D (v).

XIII. 16 ♀ *Unnamed*: albino. Second litter of Yfa dhu by Ian dhu, both white fronted, black coated Pompeks. Appeared to be albino of usual type, but whiter patch on chest. Born April 17, 1913, killed at about 2 weeks old by another dog which got into the lair in absence of mother. Hare lip, cleft palate, shrunken right orbit with no eyeball; left eye, albinotic.

XIII. 19—24 1 ♂, 5 ♀s Litter of six, dam the Pekinese albino Wee Tong (XI. 33) and sire the Pompek Donald dhu (XII. 23). Born June 21, 1912. All six surviving and healthy on March 23, 1913. Photographs of this litter at about 8 weeks are given on Plate *ζζ* (1) and (2). They show respectively the three black dogs of Pompek type, and the two reddish yellow sable dogs with the albino.

XIII. 19 ♀ *Mor dhu*: black dog of Pompek type; she has a very small white patch on belly. No white visible as she runs about. She is a small dog with head in appearance Pekinese, and might almost pass for a pure bred black Pekinese. See Plate *ζζ* (1).

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[1] The black hairs are densely packed with granules; the white hairs are perfectly clear, no diffused pigment, no granules.

[2] The buff hairs have very very pale diffused pigment and some granules (*β*), the white hairs quite clear, no diffused pigment and no granules. They match No. 20 or No. 21 on the glass mosaic scale of the Biometric Laboratory and correspond to what is frequently termed "lilac" in mice.

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XIII. 20 ♀ *Cilis dhu*: usual type of Pompek, black with a large white shirt front. As a puppy her black was far more rusty than that of XIII. 19 or XIII. 21. But this has largely passed away, and she has developed into a fairly handsome dog, with a poorer head, however, than Mor dhu. See Plate ζζ (1).

XIII. 21 ♀ *Sené dhu*: usual type of Pompek, black with a white shirt front, but in addition the left forepaw is white up to wrist. At 10 months she has the best coat of the bitches in this litter. See Plate ζζ (1).

XIII. 22 ♂ *Donnach ruadh*: a reversion to the normal Pekinese in coat colour. He has a very beautiful golden red sable coat. Black mask, black tips to tail and ears, sable saddle and tail; black mucous membrane to nose and lips, pads black, palate uniform dark grey. Chest, belly, and legs without black hairs of a golden brown, shading off to cream in the usual Pekinese hind "knickerbockers." But for the muzzle, which is not ugly as in Cilis or Sené, he would pass for a fine Pekinese in appearance. Psychically he is, perhaps, more Pomeranian; he is a nervous dog, more easily alarmed than a Pekinese and then apt to carry his tail badly, although it is usually curled over his back when running. Bark more Pomeranian than Pekinese. He is too young to judge his final form yet, but he would be usually, we think, described as a reversion to a normal Pekinese type, and to a very fine type. The hairs of Donnach as well as of his sister Giorsal (XIII. 23) contain almost every variety in density of pigment granules from none to "densely packed" (η). Some hairs have no diffused pigment, no granules; others pale yellow diffused pigment and a decided number of granules (γ), these hairs become dark brown further up and granules very plentiful (ε); some hairs have pale yellow diffused pigment with a few granules (β), while the black hairs have very dark diffused pigment and a mass of granules (η). Almost the same system applies to the descriptions of Giorsal's hairs, which often vary along the length of the hairs themselves. For photograph at 10 months: see Plate ζζ (7).

XIII. 23 ♀ *Giorsal ruadh*: golden red sable coat, a reversion to the normal Pekinese. She may be described almost in the same terms as Donnach ruadh (XIII. 22), but her tint generally is redder. A remarkably fine dog. For microscopic examination of her hair see under XIII. 22. See Plate ζζ (2).

XIII. 24 ♀ *Mor bhan*: albino. She has the usual characters of the Pekinese albino except in head shape, which is ugly and suggests the hybrid. Her coat at present (March, 1913) is cream, with a dorsal reddish streak rather like the coats of the semi-albinotic dingoes. Her ears are short, and she is apt to carry her tail drooping; she is a very nervous and timid dog, and has not at present the pugnacity behind the nervousness of her mother Wee Tong (XI. 33). See Plate ζζ (2).

No golden red sables other than XIII. 22 and 23 have appeared in the Pompek × Dondo class, but one similar dog, Sheila (XIII. 31), has been bred by C. H. Usher from Pompek × Pompek. It will be a point of much interest to ascertain whether these sable reversions will now breed true as far as coat colour is concerned.

XIII. 25—29 1♂, 4♀s This is our first litter of Pompek × Pompek, the sire being Donald dhu (XII. 23) and the dam Buna dhu (XII. 30). They were born October 28, 1912. The four females died the same day, the male lived for three days. They were of very different weights and sizes. The coats are all dark with white shirt fronts. The colour at first sight would be termed black, but there appears in each to be a shade of red though it varies in intensity. Such a tinge may be noted in some of the adult dogs. Thus in Cilis (XIII. 20) it led to her being classed as a puppy as "rusty black"; as an adult the reddish tinge can just be detected, although the casual observer would certainly call her black. It is not very easy to determine from the puppy coat what the adult coat will ultimately be, as the second coats are often much modified in tint. But the brindle, which becomes the sable, is fairly differentiated from the "rusty" black even at one or two days. We may take it that the whole of this litter were Pompeks of the usual type—the coats have been preserved. The rusty tinge spoken of is scarcely perceptible in the first pup (XIII. 25), rather more in the third (XIII. 27), quite marked in the second pup (XIII. 26), and most marked in the fourth (XIII. 28) which is distinctly lighter in colour, although this is not certainly due to more red. It exists also in the fifth pup (XIII. 29). The unopened enucleated eyes appear with transmitted light to have pigment in the iris and ciliary body, but the posterior part of the eye is very translucent. Photographs of the dead puppies are given on Plate ηη (4) and (5).

The hairs of all these five pups were microscopically examined. Every one of them had black hairs showing brown diffused pigment. Intradermal sections of the hairs showed plentiful brown granules. XIII. 25 had hairs with densely packed granules (η), so also had XIII. 29. XIII. 27 and 28 only reached the category ε, *i.e.* granules very plentiful; while XIII. 26 had two types of hairs, some with granules very plentiful (ε), and others with granules densely packed (η). This is not wholly in accordance with the macroscopic appearance, but there is a possibility that differences of coat would have developed with adult life.

The eyes of XIII. 28 were microscopically examined and will be found described in Appendix D (vi).

XIII. 25 ♀ *Unnamed*: usual type of Pompek, white front. Pup 1. Length from forehead to tip of tail 7¾″, weight 9 oz. Coat is almost black and loose over head and dorsum of body; great depth of muzzle causing head to look anencephalic. Hairs short, smooth and straight; an irregular white area on chest

Index No. Sex Name, Description, Ownership and Remarks.

extending from supra-sternal notch downwards nearly to ensiform cartilage and outwards nearly to axillae; it extends rather further up on left side of mid-line than it does on right. Mucous membrane of nose black.

XIII. 26 ♀ *Unnamed*: usual type of Pompek, white front. Pup 2. Length from forehead to tip of tail $7\frac{1}{8}''$, weight $5\frac{7}{8}$ oz. Coat black with faint suspicion of red, small white ovoid patch on chest. Coat, smooth, hairs straight. Mucous membrane of nose partly pink[1] with same distribution as in Pup 4 (XIII. 28).

XIII. 27 ♀ *Unnamed*: usual type of Pompek, white front. Pup 3. Length from forehead to tip of tail 6″, weight $2\frac{3}{4}$ oz. Coat nearly black, faintly red with same appearance generally as XIII. 25 and 26. Small **T**-shaped white patch at upper part of chest in mid-line (see Plate ηη (5)). Paw of left forefoot below level of "thumb" is white. Paw of right forefoot is black, but ends of the two central toes are white. In appearance it has a longer nose than XIII. 25, 26 and 28. Mucous membrane of nose black.

XIII. 28 ♀ *Unnamed*: usual type of Pompek, white front. Pup 4. Length from forehead to tip of tail 6″, weight $3\frac{1}{4}$ oz. Coat black with tinge of red. Long bare diamond-shaped white patch on chest beginning half down the throat and extending to xiphoid; length $= 1\frac{3}{4}''$, breadth $\frac{7}{8}''$; no other white patches (see Plate ηη (5)). Coat smooth, hairs short. Mucous membrane of nose is pink at lower part of nostrils over columella and pink extends to upper lip in mid-line; alae are black[2].

XIII. 29 ♂ *Unnamed*: usual type of Pompek, small white front. Pup 5. Length from forehead to tip of tail $7\frac{7}{8}''$, weight $5\frac{3}{4}$ oz. at death Oct. 31, 1912. Coat, short sleek, smooth; black with faint tinge of red; only white part on coat is a diagonal streak $\frac{3}{4}''$ in length on right side of chest well forward and a short white streak on left side corresponding to centre of first streak. The two streaks converge posteriorly so as to form an incomplete **V**: see Plate ηη (4). Mucous membrane of nose is black.

XIII. 30—32 Second litter of Pompek × Pompek, the sire being Ian dhu (XII. 25) and the dam Yfa dhu (XII. 33). Unfortunately two out of the three again did not survive. Born November 1, 1912.

XIII. 30 ♀ *Unnamed*: usual type of Pompek, with white front. Length from forehead to tip of tail $5\frac{2}{5}''$, weight $2\frac{3}{8}$ oz. Coat black with faint red tinge. Hairs smooth and glossy. White patch on chest **T**-shaped, vertical limb of **T** extends from supra-sternal notch to xiphoid, and the horizontal limb stretches from one axilla to the other; all of left foot is white; the four toes of right forefoot are white but not "thumb" or part above thumb level. Mucous membrane of nose all black. The black hairs show brown diffused pigment, densely packed with granules (η); the white hairs no diffused pigment, no granules. These results are true when sections are taken of the intradermal hairs. Eyes normally pigmented[3].

XIII. 31 ♀ *Sheila*: dull brown sable, not so brilliant as Donnach ruadh (XIII. 22) or Giorsal ruadh (XIII. 23), but like them a reversion to the Pekinese normal type. For portrait: see Plate ζζ (6) and (8). Coat: back, sides, head and legs sable or wolf sable, some black along spine. Muzzle and lower part of forehead black. Chest, colour like that of Persian cat or blue hare. Ears black at tips and in concavity; sable on convexity; mucous membrane of nose black. Iris, dark brown; opacity on outer part of each cornea. She has a mind of her own and some temper. Her left forelimb is quite markedly shorter and altogether smaller than her right forelimb. She runs quite well when going quickly; cause of this condition unknown.

XIII. 32 ♂ *Unnamed*: incomplete albino. Large pup died November 2, 1912; death appears to have been caused by suffocation; lungs dark with haemorrhages on them. Length from forehead to tip of tail 8″, weight $6\frac{1}{4}$ oz. Coat almost the "lilac" of XIII. 15 or of the mouse classification, and greyer than the brown of coat in Plate ψ of Fum; a marked contrast to that of the cream albino coat on the same plate. Whether this coat would become cream with age, it is not easy to determine. There is on the chest a pure white patch which extends from supra-sternal notch to xiphoid cartilage, and above, it extends laterally close to axillae. Mucous membranes of nose and mouth pink. Eyes albinotic, iris grey and translucent, rest of eye very translucent[3]. The colour of coat is almost the same as that of the albino skewbald XIII. 15 figured in Plate ω. We have marked it on chart as an incomplete albino, although it is possible that in both cases the "lilac" would have grown fainter. See Plate ηη (3) for a photograph of this albino and of his litter-sister XIII. 30. The darker hairs show microscopically a very pale straw-coloured diffused pigment, but no granules; the white hairs neither diffused pigment nor granules. This is equally true when sections are taken of the intradermal hairs.

XIII. 33—35 2 ♂s, 1 ♀ Second litter of Dido, XI. 39, by Donald ban, XII. 18. Born April 10, 1913.

XIII. 33 ♂ *Unnamed*: whole black Pompek. Died April 15, 1913. Coat black, no white hairs anywhere, feet and chest alike devoid of them. Coat smooth, tail straight. Mucous membrane of nose black.

XIII. 34 ♂ *Unnamed*: usual type of Pompek with white front. Died April 15, 1913. Coat smooth and black. No white on any of the feet. White elongated area on chest 1″ long, which extends nearly to xiphoid cartilage, and forms an imperfect diamond with a short process to each axilla.

XIII. 35 ♀ *Unnamed*: usual type of Pompek with white front. Died April 29, 1913; eyes dark. Coat black, white patch on chest, some white hairs on the two middle toes of all feet, most marked on left forefoot, very faint on others. Mucous membrane of nose and all feet pads black.

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[1] A like parti-coloured nose appeared in Cilis (XIII. 20), but quickly disappeared. Her nose is now wholly black.

[2] See footnote immediately above.

[3] For microscopic examination of the eyes: see Appendix D (vi).

APPENDICES TO *ALBINISM IN MAN*, PART II.

APPENDIX A.

EXAMINATION OF THE SKIN OF A XANTHOUS NEGRO.

By William Bulloch, M.D., F.R.S.

I received from Professor Karl Pearson a bottle containing two large pieces of skin, the one from a normal negro, the other from a so-called xanthous negro. There was a striking difference in the macroscopic appearances presented by the two, the xanthous skin, which involved the pubic region, being of a reddish brown colour with brown hair, whereas the normal negro skin was almost black. I removed pieces from the two specimens and examined them side by side by a variety of methods in order to see whether there were differences and in what these differences consisted. The skins had been fixed in formalin but were in a satisfactory state for cutting. I washed some of the pieces in running water for 24 hours, others I passed into spirit at once. Sections were cut by the freezing method or after embedding in paraffin. In several paraffin blocks the two skins were placed side by side so that they were under the same conditions during the section cutting and staining processes. Many of the sections were examined unstained after being mounted in Canada balsam, others were stained by neutral red, others again by Twort's stain, consisting of neutral red and light green, which gives unusually fine pictures clear and sharply defined. The pigment in the two skins in sections was investigated by means of hydrogen peroxide in the form of Merck's perhydrol, potassium permanganate (0·25 per cent. sol.) and by antiformin, to see whether there were any chemical differences in the pigment in the two series. In unstained sections examined with Leitz obj. 3, eyepiece 4, it is at once apparent that the negro skin is much more pigmented than the xanthous skin. This difference is strikingly marked in the deep layers of the rete Malpighi where the pigment is so concentrated as to fairly permit the designation of black. In the xanthous skin even where the pigment has accumulated most it is brown, or golden brown. Throughout the remaining layers of the epithelium pigment granules are distributed, being however much greater in the negro than in the xanthous skin. In both skins a considerable number of pigmented cells (chromatophores) can be seen in the cutis. With Leitz obj. $\frac{1}{12}$ and eyepiece 8, the two skins were subjected to a close scrutiny, many sections being examined. Under this condition the pigment of the negro skin appears brown whereas the pigment of the xanthous skin is golden yellow. The pigment in each case penetrates all the layers of the epithelium, being however much more sparse in the xanthous as compared with the negro skin. The pigment is granular in both cases, this applying to the epithelial as well as to the chromatophoric tissue.

In sections stained with neutral red or Twort's stain, a clearer view of the cellular relations of the pigment is obtained and after a careful scrutiny I believe I am justified in asserting that the difference between the xanthous and negro skin is one of degree rather than of kind. By embedding the sections in the same block of paraffin the sections were of the same thickness and were both under the same field of the microscope at the same time, so that they could be accurately compared. Considering that there might be some chemical differences I employed some of the bleaching reagents mentioned above, but in both cases the granules disappeared, being ultimately decolorised. In the xanthous skin some hair follicles were seen with sections of hairs in which there was a considerable quantity of pigment granules as well as some diffuse yellowish colouring matter[1].

APPENDIX B.

(A) REPORT ON THE EYES OF A SEMI-ALBINOTIC DINGO[2].

By George Coats, M.D.

Fixed in Zenker's solution and afterwards transferred to 70 °/$_\circ$ alcohol. One globe was divided vertically, the other horizontally. There is no naked-eye appearance of albinism in either fundus.

(i) *Stroma Pigment.*

Iris. In the most anterior layers, where there is normally a considerable concentration of pigment, a small quantity only is present, partly within cells, partly in the form of scattered granules. In the underlying layers, forming about half the thickness of the iris, pigment is very scanty. In the posterior half it becomes more abundant, mostly in the form of small round masses (? clump cells) but with an intermixture of branched chromatophores. Even here, however, the depth of pigmentation is decidedly less than in the normal dog's eye. Towards the pupillary margin chromatophores become relatively more abundant and more evenly distributed. The layer of the dilatator is comparatively free from pigment. The tint of some of the chromatophores seems to be lighter than normal; of others normal.

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[1] [An examination of a specimen of hair from the scalp of the same negro was made by E. Y. Thompson in the manner discussed in our chapter on Albinotic Hair. Examined microscopically there are found to be a mixture of various hairs from pale yellow to light brown. The granules range in these hairs from "some" (β) to a "decided number" (γ), the former corresponding to the hairs with yellow, the latter to the hairs with brown diffuse pigment. The hairs are patchy; the diffused pigment is in light and dark patches, and the granules also are inclined to group in frusta. K. P.]

[2] This is the albinotic Dingo received from Mr Tyrwhitt Drake: see p. 461.

Ciliary Body. The anterior portion is pigmented very slightly, and chiefly in its inner layers. (This distribution is normal.) Among the bundles of the ciliary muscle there is a good deal of pigmentation, but less than in the normal eye. The pigmented cells are nearly all rounded in form and are full-tinted.

Choroid. The pigmentation is not much, if at all, lighter than normal. The cells have their normal horizontally elongated form, and their colour is full.

Sclera. The pigmentation at the corneo-scleral junction, nerve-entrance, etc., is quite up to the average.

(ii) *Pigment Epithelium.*

Owing to faulty fixation (and ? early post-mortem change) the epithelium has stripped extensively, but where present it shows a normal degree of pigmentation.

Pigmentation is therefore present in all the normal situations, but in some of them is lighter than usual. The condition is practically identical in the two eyes.

(B) REPORT ON THE EYES OF A NORMAL, AND OF A SEMI-ALBINOTIC, DINGO[1].

By GEORGE COATS, M.D.

With the naked eye there is no evident difference between the two eyes, except that the membrana nictitans is rather more pigmented in the normal.

(i) *Stroma Pigment.*

Iris. In the albinotic dingo's iris there is a narrow deeply pigmented layer on the anterior surface, beneath this a layer of relatively unpigmented stroma occupying from one third to one half of the thickness of the iris, the rest of the thickness being composed of a tissue very thickly crowded with branched chromatophores.

In the normal animal the anterior layer shows about the same depth of pigmentation, the intermediate layer contains rather more numerous and more darkly pigmented cells, and the posterior layer is decidedly more heavily pigmented, both as regards the number of chromatophores and the depth of their pigmentation.

Ciliary Body. In the albinotic eye the ciliary body may be divided into a part anterior to the ciliary muscle which is relatively free from pigment, and the portion corresponding to the ciliary muscle where pigmentation is deep among the muscle bundles. In the normal eye the pigmented cells are somewhat more numerous in the anterior portion; in the posterior portion the amount seems to be the same, and the colour darker, but the muscle is poorly developed and the tissues are rather shrunken making an exact judgment difficult.

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[1] These dingoes, one normal and one semi-albinotic, were kindly sent to K. Pearson by Mr Minchin of the Adelaide Zoological Gardens at the suggestion of Dr H. Rischbieth.

Choroid. In the choroid the amount of pigmentation, generally speaking, is approximately the same in the normal and albinotic eyes. In the albinotic eye, however, there is an area of considerable extent on one side in which pigment is almost completely absent. This area is beneath the tapetum. (Normally in the dog and other animals the stroma is well pigmented, but the retinal epithelium contains no pigment, in the region of the tapetum.)

Sclera. Both at the sclero-corneal margin and further back there is more pigment in the normal than in the albinotic eye.

(ii) *Pigment Epithelium.*

On the iris the pigment epithelium seems to be rather darker in the normal eye. On the ciliary body and choroid there is no decided difference.

The eye of this albinotic dingo stands in a position intermediate, as regards the iris at least, between the normal that accompanied it and the eye of the previous albinotic dingo. This ocular order does not quite accord with the macroscopic order of the coats, for the coat of the present semi-albinotic dingo has more pure cream than the earlier one which contains a dorsal streak of almost reddish hair. The macroscopic order of the coats is also that of the microscopic hair analysis: see p. 461 above. The difference of order in hair and eye pigmentation only indicates that the correlation of the incomplete albinism in these characters is not perfect.

APPENDIX C.

FURTHER REPORTS ON THE EYES OF ALBINOTIC BIRDS.

By C. H. Usher.

(i) *Cream coloured Thrush*[1].

Examination of eyes of a cream coloured thrush (*Turdus musicus*). The bird was a female and taken from a nest, with three normal young ones, in 1911. *Plumage*: of a pale cream colour rather darker on back than breast; coloured feathers have the colour limited to the free ends; bill and legs are of a pale indefinite yellow, they were pinkish during life. *Eyes*: iris grey and translucent; pupil red; the enucleated eyes held towards the light show marked translucency in every part; a darker though translucent zone corresponds in situation to ciliary body. The eyes were opened after hardening in 7 per cent. formalin, then embedded in celloidin. *Macroscopic Examination*: nictitating membrane is pigmentless; fundus exceedingly pale; pecten rather darker and redder than fundus. *Microscopical Examination*: no pigment in nictitating membrane; iris stroma is pigmentless, but posterior layers of iris contain a small quantity of brown pigment in fine granules

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[1] We are indebted to Dr A. R. Galloway of Aberdeen for these eyes and for those of (ii).

(Plate ι, Fig. 11); ciliary body has no pigment in stroma and only scanty pigmentation of the epiblastic pigment layer, although this is rather more pigmented than the posterior layers of iris; choroid is unpigmented; retinal pigment layer is unpigmented, no pigment being continued from ciliary body posterior to ora serrata; pecten has no trace of pigment. The only parts with pigment in the eye are the epiblastic layers of iris and ciliary body.

An eye of a thrush with usual plumage obtained on 15th February, 1912, for comparison with the albinotic thrush, had a brown iris and a pigmented nictitating membrane. *Microscopical Examination*: iris and ciliary body have much brown pigment in stroma and deeply pigmented epiblastic layers; choroid well pigmented; retinal pigment layer dark brown; pecten has much pigment especially at crest; nictitating membrane pigment abundant in stroma, some in epithelium; much subepithelial pigment at limbus corneae.

(ii) *Albinotic Greenfinch.*

Examination of the eyes of an albinotic Greenfinch (*Ligurinus chloris*—Saunders, *Chloris chloris*—Sharpe), male, age about six months, caught when a fledgling in summer of 1911, near Lumphanan, Aberdeenshire, when unable to feed itself, reared in captivity by a male canary. *Plumage*: white with patches of canary yellow; the largest yellow patch is on rump and is continued on to tail feathers; yellow is present on lesser wing coverts and outer edges of primaries; head, neck, back and breast are white with yellow intermixed, some feathers in these parts are entirely white; belly mostly white; bill pink; legs less markedly pink. *Eyes*: pupils pink; iris grey and translucent. Dr Galloway, to whom the bird belonged, says it resented the light. The eyes were placed in 7 per cent. formalin. The excised eye when held towards the light was exceedingly translucent in every part, ciliary region was slightly darker than rest of eye; after opening the eye no pigment could be detected in fundus, pecten or ciliary body, and none was seen in nictitating membrane. *Microscopical Examination* revealed no pigment anywhere in iris (Plate ι, Fig. 8) or ciliary body, in pecten or any other part of the eye; both stained and unstained sections were examined with the ordinary low and high powers of the microscope and with an oil immersion lens.

A normal greenfinch, male, obtained and killed on 5th February, 1912, for comparison with the albino bird, had a black pupil and hazel coloured iris; fundus, pecten and ciliary body are dark. Iris stroma has dark pigment which is most marked anteriorly; epiblastic layers very dark (Plate ι, Fig. 7); ciliary body stroma contains dark pigment, at attachment of ciliary muscle pigment is conspicuous; epiblastic pigment layer deeply pigmented; much dark pigment in choroid and pecten; retinal pigment layer is deeply pigmented; some pigment at limbus.

The above albinotic greenfinch is especially noteworthy; it is the *only* albino bird yet examined (see our p. 397) in which the eyes have shown a complete absence of pigment. Does albinotic man stand for ocular pigment nearer to albinotic birds, dogs and Japanese mice, than to albino rabbits and white mice?

APPENDIX D.

REPORTS ON EYES AND ORGANS OF ALBINO DOGS[1].

(i) *Examination of Eyes of Karl Pearson's Dondo Puppy Tin Lo* (Ped. XII. 15).

By C. H. Usher.

The eyes had been subjected to increasing strengths of alcohol and were received in 50 per cent. alcohol; they were transferred to 6 per cent. formalin; after opening antero-posteriorly one half of each eye was embedded in celloidin for sections. The appearances of the two eyes were the same so that one description serves for both. *Macroscopical Examination*: fundus pigmentless; at ciliary body is a dark brown zone with a well-defined margin where it joins the pigmentless fundus; anteriorly it is continuous with faint brown patchy pigmentation on posterior surface of iris. *Microscopical Examination*: iris stroma is pigmentless; its posterior layers, where present, are only sparsely pigmented; much of these layers has become detached from post-mortem change; their pigmented cells contain comparatively scanty granules; ciliary body has no stroma pigment, but epiblastic pigment layer has a moderately dark brown colour; the pigment in this layer extends posteriorly to ora serrata; choroid is unpigmented; retinal pigment layer also is unpigmented; in this layer are a number of granular cells[2], usually occurring singly, whose size varies considerably, some are plump and of an oval shape; in stained sections (logwood and eosine) they assume a brownish appearance suggesting pigment, yet in unstained sections they are almost colourless, just faintly brown, and are inconspicuous, they are then detected by their shape, granular character, situation and somewhat darker aspect than rest of fundus; their granules are finer than those found in normal cells of retinal pigment layer; these finely granular cells are present in front of the tapetum, a situation where in the normal dog no pigment exists in the retinal pigment layer; no pigment is present at sclero-corneal margin, in trabeculae of ligamentum pectinatum or in sclerotic. The only parts of these eyes that contain pigment are the epiblastic layers of iris and ciliary body.

(ii) *Examination for Pigment of Internal Organs of the Dondo Puppy Tin Lo.*

By Dr Alexander Low.

The following were received in 50 per cent. alcohol: thymus, heart and lungs, liver, spleen, pancreas, kidneys, suprarenals and pieces of skin from nipple region and from some other part. Parts of each were embedded in celloidin, and sections stained with paracarmine as well as unstained were examined microscopically. In none of the sections of any of these organs was pigment present.

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[1] References "Ped." are to the index numbers on the pedigree of Plate LVII. or to the list of dogs in Section III of Chapter XI.

[2] Possibly these are Rachlmann's "granules": see ftn. p. 287.

(iii) *Examination of the Eyes of C. H. Usher's Dondo Bitch Mairi bhan* (Ped. XI. 26). By C. H. Usher.

Pigmentation of eyes. The eyes were placed in 10 per cent. formalin immediately after killing. Both eyes were frozen and opened antero-posteriorly. *Macroscopical Examination*: anterior surface of iris is white, posterior surface brown, stroma of considerable thickness as seen in section; ciliary body brown rather darker than iris, its pigment ceases posteriorly at ora serrata forming a well-defined margin; fundus almost white, has just a faint tinge of brown. *Microscopical Examination*: iris has no pigmented chromatophores; epiblastic layers lightly pigmented; ciliary body has no stroma pigment and lightly pigmented epiblastic pigment layer; choroid has no pigment; retinal pigment layer has a pale yellow appearance, as marked at tapetum as elsewhere, in unstained sections; in sections stained with logwood and eosine it looks browner; no pigment granules found though sought for with oil immersion lens; no iron was found when the usual potassium ferrocyanide and hydrochloric acid test was applied; in a black retriever pup these appearances were not present in the retinal pigment layer.

(iv) *Report of Internal Pigmentation of the Dondo Mairi bhan* (Ped. XI. 26). By Dr Alexander Low.

All the internal organs and two pieces of skin, one from "spectacle mark," were received in 10 per cent. formalin. After three days in the formalin solution pieces of all the organs and tissues were washed in water and subsequently embedded in celloidin and sectioned. The sections were examined unstained and also after staining with paracarmine.

No granular or diffuse pigment was observed in any of the following parts:—(*a*) brain; sections were made of all the different regions and special attention given to olfactory tract and bulb[1], cerebral cortex, pituitary body, substantia nigra of mid-brain, nuclei of medulla, choroid plexuses and meninges; (*b*) lymphatic glands, thyroid, thymus, lungs and bronchial glands (these showed carbon particles in quantity), heart, liver, spleen, pancreas, kidneys and suprarenals, with sympathetic ganglia and mesentery.

The olfactory area of the nasal mucous membrane to the naked eye was of a yellowish grey colour in marked contrast to that of Tong I (see p. 405). Microscopically a distinct yellow coloration was diffused in the epithelial layer, but there were no pigment granules.

The "spectacle mark" piece of skin in section showed a diffuse marked yellow coloration in some of the hairs, other hairs were colourless. The coloured hairs were the larger hairs and when traced into the follicle the colour gradually disappeared. A tuft of hair cut off close to skin, teased out and examined microscopically showed that the coloured hairs were comparatively few. A similar result was obtained by making transverse sections of such a tuft embedded in celloidin. No pigment granules were present.

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[1] The olfactory bulb was well developed and compared favourably with that of a collie dog, also the olfactory area of the nasal mucous membrane, as judged by the diffuse coloration, was relatively large.

In the piece of skin from chest there was neither diffuse nor granular pigment.

Both internal ears were sectioned and many sections were examined microscopically; they were found to be quite normal except that no trace of pigment could be discovered.

(v) *Brief Account of Microscopical Examination of Eyes of four Puppies of Mairi dhu (Pompek) × Ian ban (Dondo).* By C. H. Usher.

The *two black and white piebald pups* (Ped. XIII. 13 and 14) have well pigmented eyes. Iris has dark epiblastic layers and well pigmented stroma; ciliary body stroma and epiblastic pigment layer are darkly pigmented; choroid contains much dark pigment; retinal pigment layer normally pigmented, as usual it has no pigment at tapetum; at limbus, brown pigment granules in the epithelium, found only in first pup. In the *cream and buff* ("*lilac*") *coated skewbald pup* (Ped. XIII. 15) the only pigmented parts of the eye are the epiblastic pigment layers of iris and ciliary body. These parts are lightly pigmented with brown granules. The pigmentation ceases at ora serrata. The pigmented layers of iris and ciliary body are very much paler than the dark corresponding layers of the black and white piebald pups. The posterior of the two epiblastic layers of iris has no pigment at root of iris. *The fourth dead pup, a black one with white on chest* (Ped. XIII. 12), has well pigmented eyes with distribution of pigment the same as in the two black and white piebald pups; dark pigment is present in epithelium at limbus corneae.

(vi) *Examination of the Eyes of Puppies of the second Hybrid Generation (Pompek × Pompek), Buff Albino (white chest) and Black Dogs.* By C. H. Usher.

I have examined with the microscope three eyes from three of the pups of the last litters.

The albino pup (Yfa dhu's pup, Ped. XIII. 32) has the pigment distributed in the same way as in the eyes of the Pekinese albino dogs. The only parts of the eye containing pigment are the posterior (epiblastic) layers of the iris and the pigment layer of the ciliary body. These layers are not nearly so deeply pigmented as in the eyes of the next two (not albinotic) pups.

The eye of Yfa dhu's pup (Ped. XIII. 30), has darkly pigmented posterior layers of iris and a quantity of stroma pigment; at limbus there is darkly pigmented epithelium; ciliary body has a dark epiblastic layer and much pigment in stroma; choroid well pigmented, not so much pigment posteriorly; retinal pigment layer well pigmented.

Buna's pup (Ped. XIII. 28) has same distribution of pigment as pup XIII. 30 of Yfa dhu, but there is much less pigment in choroid and I think less stroma pigment in iris and ciliary body. Whether there is less pigment in these last two pups' eyes than in a newly born Pomeranian pup's eye has not been determined. A newly born Pomeranian pup has not yet been obtained for comparison.

APPENDIX E.

REPORT ON THE EYES AND INTERNAL ORGANS OF A SEMI-ALBINOTIC CAT.

By C. H. Usher and Dr Alexander Low.

(i) *White Cats with blue Eyes and Deafness.*

That white cats with blue eyes are usually deaf was pointed out by Blumenbach[1] in 1830 and by Darwin[2] in 1876. Sichel[3] kept a young, quite white, cat with blue iris and complete deafness. After four months the iris became darker and the animal showed some signs of hearing, but further observations were prevented by the cat escaping into the street, where it was killed by a dog which it had not seen and whose bark it had not heard. Francis Galton[4] referred to the matter again in 1885.

Microscopical examination of the ears and brain of a cat that was white, with the exception of black spots on the ears, was made by Alexander[5] in 1900. The cat was deaf; iris yellow; choroidal pigment was present; mucous membrane of roof of mouth unpigmented; skin white, except small blackish spots on ears. There were four embryos in the uterus. One, a male, was white like the mother; the other three, females, were striped dark brown. Alexander found pathological changes only in the labyrinth and auditory nerve of the mother. The walls of the membranous labyrinth were collapsed, the special nerve endings were degenerated and there was total absence of pigment in the labyrinth. There was hyperplasia of the cochlear nerve (? atrophy).

Abelsdorff[6] in 1904 described the eyes of two white deaf cats. In the first cat the iris was light blue on each side; pupils contracted readily to light; no apparent disturbance of vision; right fundus appeared to be normal with a tapetum present; left fundus had no tapetum, so that in upper part of the fundus, as seen with the ophthalmoscope, choroidal vessels on a whitish ground were visible. The second cat, like the first, had normal vision and pupil reactions; refraction hypermetropic. Right iris was yellow with greenish colour at pupil edge. Left iris pale blue. The right eye had a tapetum; in left eye no tapetum was found on ophthalmoscopic or anatomical examination.

Beyer[7] in 1905 examined the ears microscopically of two white deaf cats. The first had a light blue iris in each eye. The second had a light blue iris in left eye and in the right eye a yellow iris with greenish colour at pupil; tapetum was absent in the left eye as determined during life. Beyer found in the ear similar changes to those described by Alexander involving the membranous labyrinth and the cochlear nerve. He makes no special reference to presence or absence of pigment.

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[1] *Handbuch der Naturgeschichte*, S. 90, Göttingen, 1830.

[2] *Origin of Species*, 1885 Edn., p. 9.

[3] *Annales des sciences naturelles*, 3rd series, Zoologie, vol. 8, p. 239, Paris, 1847.

[4] See Bibl. No. 593.

[5] *Archiv für Ohrenheilkunde*, Bd. L. S. 159, Leipzig, 1900.

[6] *Archiv für Ophthalmologie*, Bd. LIX. S. 376, 1904.

[7] *Archiv für Ohrenheilkunde*, Bd. LXIV. Heft 4, S. 273, Berlin, 1905.

Alexander and Tandler[1], in 1905, confirm the microscopical changes which Alexander had found in the middle ear of deaf white cats.

(ii) *A deaf, white Cat with Heterochromia Iridis.*

This cat, which was sent to us alive by K. Pearson, was a quite deaf adult male[2]. Its mew, a deep melancholy short note, was different from that of a normal cat; coat was completely white; whiskers white; nose pink; no pigment in mucous membrane of mouth. Right eye: iris uniform light yellowish green; pupil black, except in certain positions in which a greenish iridescence was seen, but no red reflex. Seen by the ophthalmoscope the fundus was dark red and had a green iridescent tapetum. Left eye: iris pale blue grey, looks thin and translucent, dark narrow ring at pupil margin; marked red reflex in pupil; fundus appeared, with the ophthalmoscope, to be completely albinotic; choroidal vessels markedly exposed and the parts between the vessels are white, this condition was seen at all parts of the fundus; no evidence of a tapetum. No nystagmus; no photophobia; pupils equal and contract to light.

The animal was killed with chloroform, skinned and dissected. The organs were placed in 10 per cent. formalin.

(iii) Dr Alexander Low has made the following report on the ears, brain and other organs, excepting the eyes. *Ears.* The pinnae and external auditory meatus showed no peculiarity. Each temporal bone was removed entire, the middle ear opened up, the membrana tympani and tympanic ossicles examined and found normal. The petrous portions of both temporal bones were fixed in 10 per cent. formalin solution, and after hardening in alcohol embedded in celloidin; the right temporal bone was decalcified before embedding, the left after embedding in celloidin —10 per cent. nitric acid in salt solution and alcohol was used as the decalcifying agent. Sagittal sections were made of both temporal bones, and the sections were mostly stained with haematoxylin and eosin, but some were examined unstained. The sections through the left internal ear were not quite successful, being cut in a somewhat oblique direction.

The microscopic examination of these sections showed no degeneration of the auditory nerve; the vestibular division with its ganglion and the cochlear division with the spiral ganglion being apparently quite normal. There was no defect of the bony labyrinth, and the membranous labyrinth as regards structure was practically normal. There was no obliteration or collapse of the cochlear canal, and as regards the organ of Corti the only departure from the normal that could be noted was that it seemed to be somewhat flattened with the membrana tectoria pressed down upon it—this appearance may have been brought about in the process of embedding, as the appearance was similar to that I had seen in the ear of normal kittens. There was a complete absence of the light brown pigment normally present in the perilymphatic tissue of the internal ear of the cat.

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[1] *Archiv für Ohrenheilkunde*, Bd. LXVI. S. 161—179, Leipzig, 1905.

[2] This *complete* deafness is opposed to Przibram's statement that there is correlation between the blue eye and deafness on each side, a cat with one blue, one yellow eye being only deaf on the blue side: see *Archiv für Entwicklungsmechanik*, Bd. XXV. S. 260—5, Leipzig, 1907.

The above account of the microscopic appearances refers to both ears. Thus, except for the entire absence of pigment and the slight flattening of the organ of Corti, both ears are normal.

The naked eye appearances of the brain were noted and microscopic sections, stained and unstained, of cerebrum, pituitary body, cerebellum, midbrain, pons Varolii and medulla oblongata were examined. The convolutions of brain, including the temporal, when compared with those of a normal cat were quite unaltered. The various parts of brain on microscopic examination were found to be normal except for the complete absence of pigment.

The olfactory mucous membrane examined macroscopically and microscopically showed no trace of pigment.

The suprarenal capsules showed no pigment granules in the cells of the cortex, but the medulla to the naked eye and microscopically showed a diffuse light yellow coloration.

Sections of thymus, lungs, liver, kidney, pancreas, testis and a lymph gland from abdomen were examined microscopically and found normal. No pigment was present in any of the sections.

The skin and hair contain neither diffuse nor granular pigment.

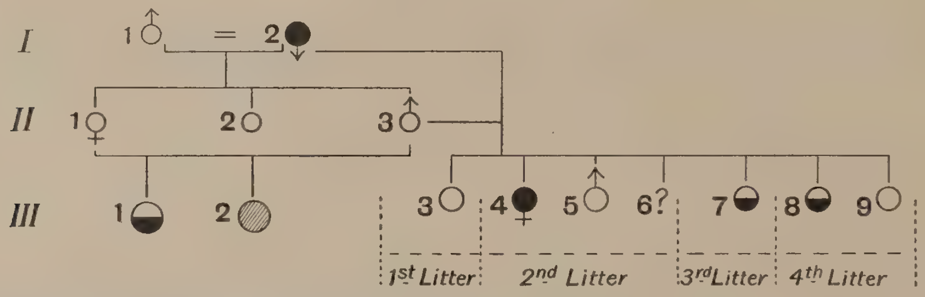
(iv) The eyes had been placed in 7 per cent. formalin and then opened equatorially. The part of the right fundus above the optic disc had a pale blue grey appearance (retina *in situ*), below the optic disc the fundus was darker. The fundus of the left eye was so pale that no pigment could with naked eye be said to be present except here and there close to ciliary region, where light brown pigment was visible. Ciliary region quite dark in both eyes.

Both halves of the eyes were embedded in celloidin and cut sagittally for microscopical examination.

Right eye: no pigment present at limbus, but there is much dark pigment at deep part of sclero-corneal junction. Iris stroma cells are light yellow and very finely granular; epiblastic posterior layers are deeply pigmented, they turn forwards at pupil to form its margin, and from their anterior surface darkly pigmented processes or "spurs" project into the stroma; numbers of dark bodies with coarse pigment granules lie in the stroma close to the pigment layers, some are elongated, others round "clump cells," amongst these cells are separate dark pigment granules. Ciliary body has dark brown stroma cells; epiblastic pigment layer is dark and there are some clump cells. Retina has a well pigmented layer, the cells containing brown pigment except at tapetum, where they are pigmentless although of normal size and shape. Choroid darkly pigmented. At optic nerve entrance is much dark pigment around the blood-vessels.

Left eye: no pigment found at limbus or at posterior part of sclero-corneal junction. Iris posterior layers and other derivatives of the epiblast are darkly pigmented as in right eye, but there is complete absence of pigment from the chromatophores. Ciliary body contains no stroma pigment; in other respects its pigmentation is similar to that in the right eye. Choroid is unpigmented. No pigment present at optic nerve entrance. Retinal pigment layer, as seen in the sections, is as dark as in the right eye. At the usual situation of the tapetum the polygonal cells are unpigmented, although of normal appearance in other respects. At this region the choroid is much thinner than in the right eye (less than half) and blood-vessels are present close to retinal epithelium. Judging by the sections the tapetum is absent, or if represented at all is much attenuated. The left eye, with blue iris, differs from the right eye in having complete absence of pigment in mesoblastic structures and in absence of tapetum.

The family history of this cat is not known. The following small pedigree[1] of another deaf, white cat with blue iris has most kindly been sent by Dr Stannus[2]. Full particulars could not be given as some kittens were drowned.



I. 1 half-bred English Tabby (?), I. 2 imported Persian cat with blue eyes, deaf. II. 1, II. 2 and II. 3 yellow eyes, long white hair, not deaf. II. 3 mated with his sister II. 1 gave III. 1 long white-haired cat with one eye blue, the other yellow, not deaf, and III. 2 not seen. Afterwards II. 3 mated with his mother I. 2; there were four litters. In the first III. 3 had yellow eyes; in the second III. 4 was white with both eyes blue, deaf; III. 5 was white both eyes yellow, not deaf; in the third III. 7 was white, had one yellow and one blue eye; in the fourth III. 8 was white and had one yellow and one blue eye, while III. 9 was white with two yellow eyes.

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[1] Three other small pedigrees are given by Hans Przibram ("Vererbungsversuche über asymmetrische Augenfärbung bei Angorakatzen." *Archiv für Entwicklungsmechanik*, Bd. xxv. S. 260—5, Leipzig, 1907). They show that blue-yellow × yellow-yellow may get blue-blue, blue-yellow or yellow-yellow eyed offspring; blue-blue × blue-yellow may also get all three types; and blue-yellow × blue-yellow may get blue-blue and blue-yellow; probably the latter could also get yellow-yellow, but there was only one cross resulting in two kittens. He also gives an interesting human eye-colour pedigree, but the asymmetry was not inherited.

[2] In letters to K. Pearson from Zomba, Nyasaland, January—March, 1911.

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CORRIGENDA TO PLATES

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(8). *For* XII. (17) *read* XII. (18).

Plate ψ. Below right skin *for* XI. (12) *read* XI. (11).

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Fig. 1. Normal Yellowammer (*Emberiza citrinella*), fundus and pecten × 39. The space at posterior part of section is artificial. *R* = retinal epithelium, *Ch* = choroid, *Scl* = sclerotic, *P* = pecten. See p. 387 of text, footnote.

Fig. 2. Albinotic Yellowammer (*Emberiza citrinella*), fundus and pecten × 39. Crest of pecten is not shown in the drawing. There is no pigment in choroid, pecten and retinal pigment layer, but posterior layers of iris are pigmented. See p. 394.

Fig. 3. Normal Hedge-Sparrow (*Accentor modularis*), retina and choroid × 180.

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Plate ρ. Sections of Albino Negro's Eye and of Albino Pekinese Spaniels' Eyes (Coloured). For description see Part II. p. 403.

Plate σ. (1) Partial Albinism in a *Counochaetes Gnu.* (2) Albino Buffalo Calf. (3) Adult Female Norwegian Variable Hare. For description see Part II. p. 425.

Plate τ. (1)—(3) Basutoland Piebald and Albinotic Family. For description see Part IV. Extra Pedigrees, Fig. W. (4) and (6) Piebaldism in Dogs of Albinotic Ancestry. For description see Part II. pp. 509, 510. (5) Pomeranian Bitch Olga. For description see Part II. p. 503.

Plate υ. (1)—(18) Albino Pekinese Spaniels = Dondos. For descriptions see Part II. Chapter XI. Section III. under individual Pedigree Numbers.

Plate φ. (19)—(26) Less complete Albino Pekinese Spaniels. For descriptions see Part II. Chapter XI. Section III. under individual Pedigree Numbers.

Plate χ. (27)—(36) Pompeks = Hybrids of Dondos and Black Pomeranians. For descriptions see Part II. Chapter XI. Section III. under individual Pedigree Numbers.

Plate ψ. Skins of Complete and Incomplete Dondo Puppies. For descriptions see Part II. Chapter XI. Section III. under individual Pedigree Numbers.

Plate ω. Skins of Skewbald and Piebald Puppies of Pompek and Dondo Crosses. For descriptions see Part II. Chapter XI. Section III. under individual Pedigree Numbers.

Plate αα. Skins of Piebald and usual type Pompek Puppies of Pompek and Dondo Crosses. For descriptions see Part II. Chapter XI. Section III. under individual Pedigree Numbers.

Plate ββ. The Honduras Piebald. Photographs by M. Le Comte Maurice de Périgny. For description see Part IV. Extra Pedigrees, Fig. Y, and compare Plate εε.

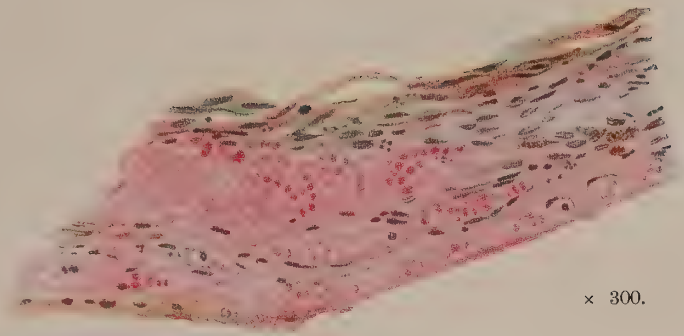
Plate γγ. Wakamba Albino Girl, Dr Arthur's Case. Leucotic patches on nipples and areolae of a Hindu. Major W. F. Harvey's Case.

Plate δδ. (1)—(3) Kukumku Albino Girl, South Nigeria. N. W. Thomas' Case. (4)—(6) Eša Woman, South Nigeria. Nearly complete Leucosis, described as 'congenital' Leucoderma. N. W. Thomas' Case.

Plate εε. Honduras Piebald from photographs taken for K. Pearson. Compare Plate ββ. For description see Part IV. Extra Pedigrees, Fig. Y.

Plate ζζ. (1)—(8) Dondo and Pomeranian Hybrids. For descriptions see Part II. Chapter XI. Section III. under individual Pedigree Numbers.

Plate ηη. (1)—(2) Skins from Skewbald Puppies, Dondo × Dondo. (3)—(5) Dondo and Pomeranian Hybrids. For descriptions see Part II. Chapter XI. Section III. under individual Pedigree Numbers.



× 300.

Fig. (i).

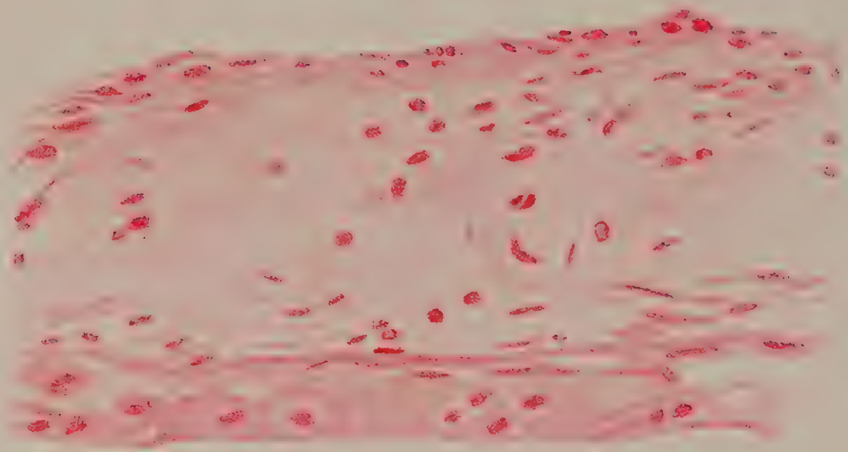
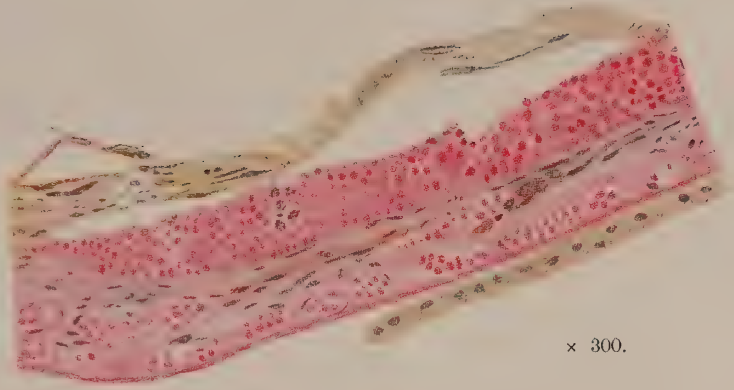


Fig. (iii).

× 600.



× 300.

Fig. (ii).

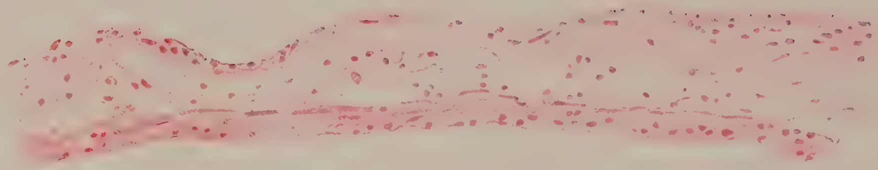


Fig. (iv).

× 200.

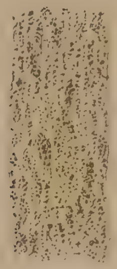
Figs. (i) and (ii).—Sections of Choroid of V. 5 in Pedigree No. 2.

Figs. (iii) and (iv).—Sections of Iris of III. 12 in Pedigree No. 256.

Sections of the Human Albinotic Eye.

Adlard & Son, Impr.

Plate β.



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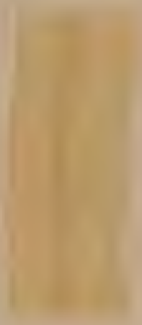

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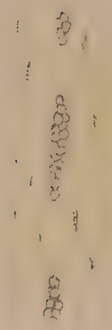

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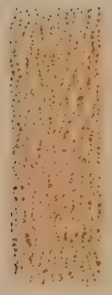

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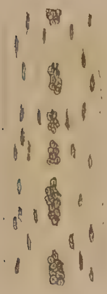

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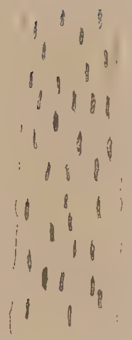

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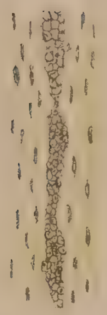

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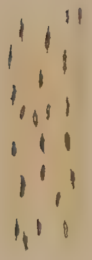

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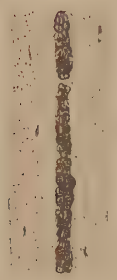

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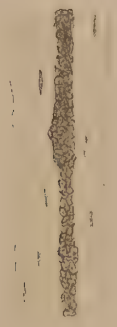

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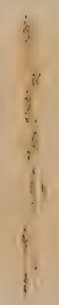

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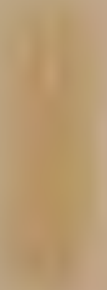

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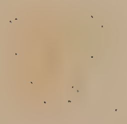

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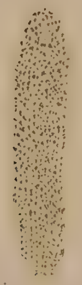
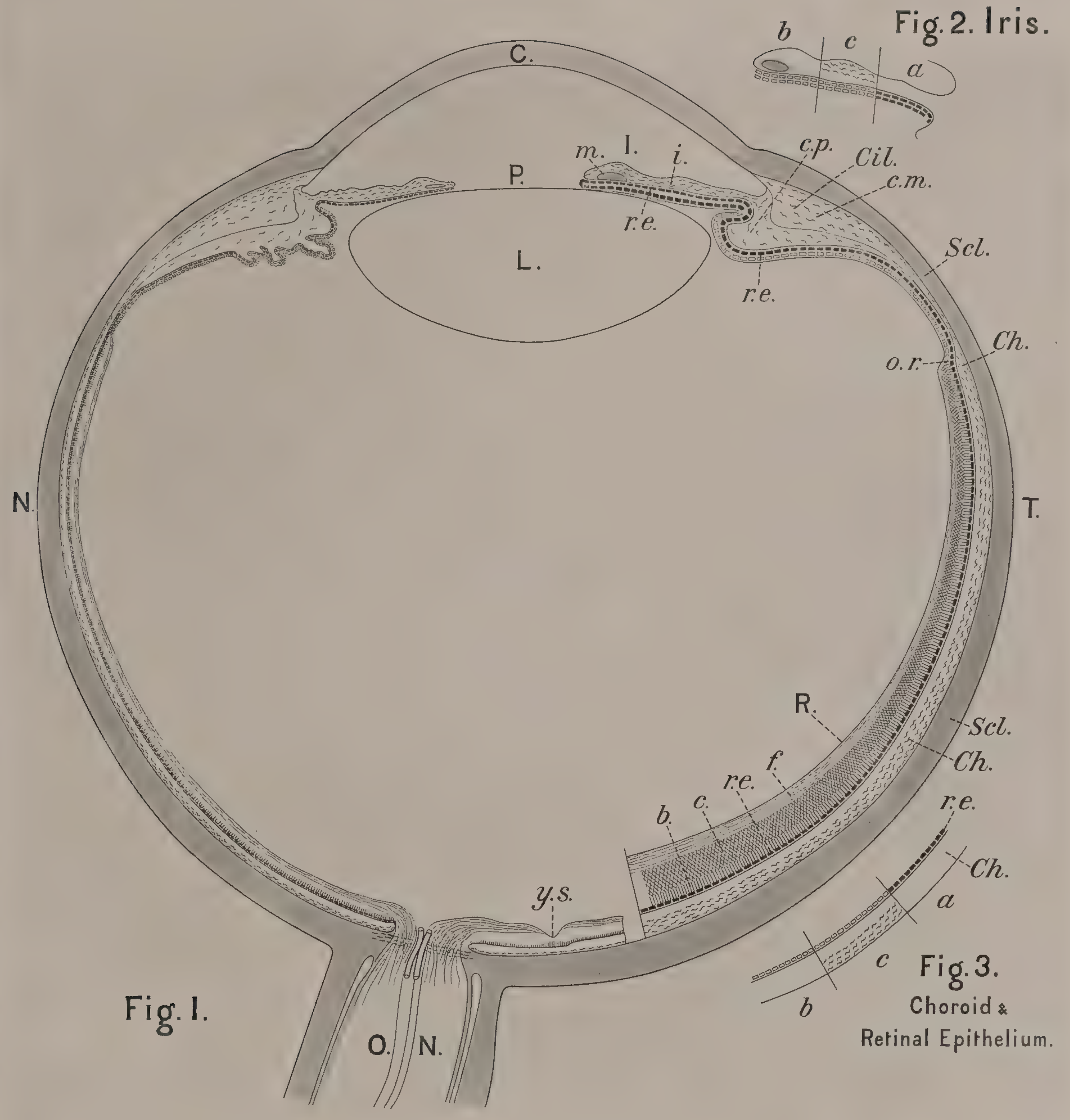
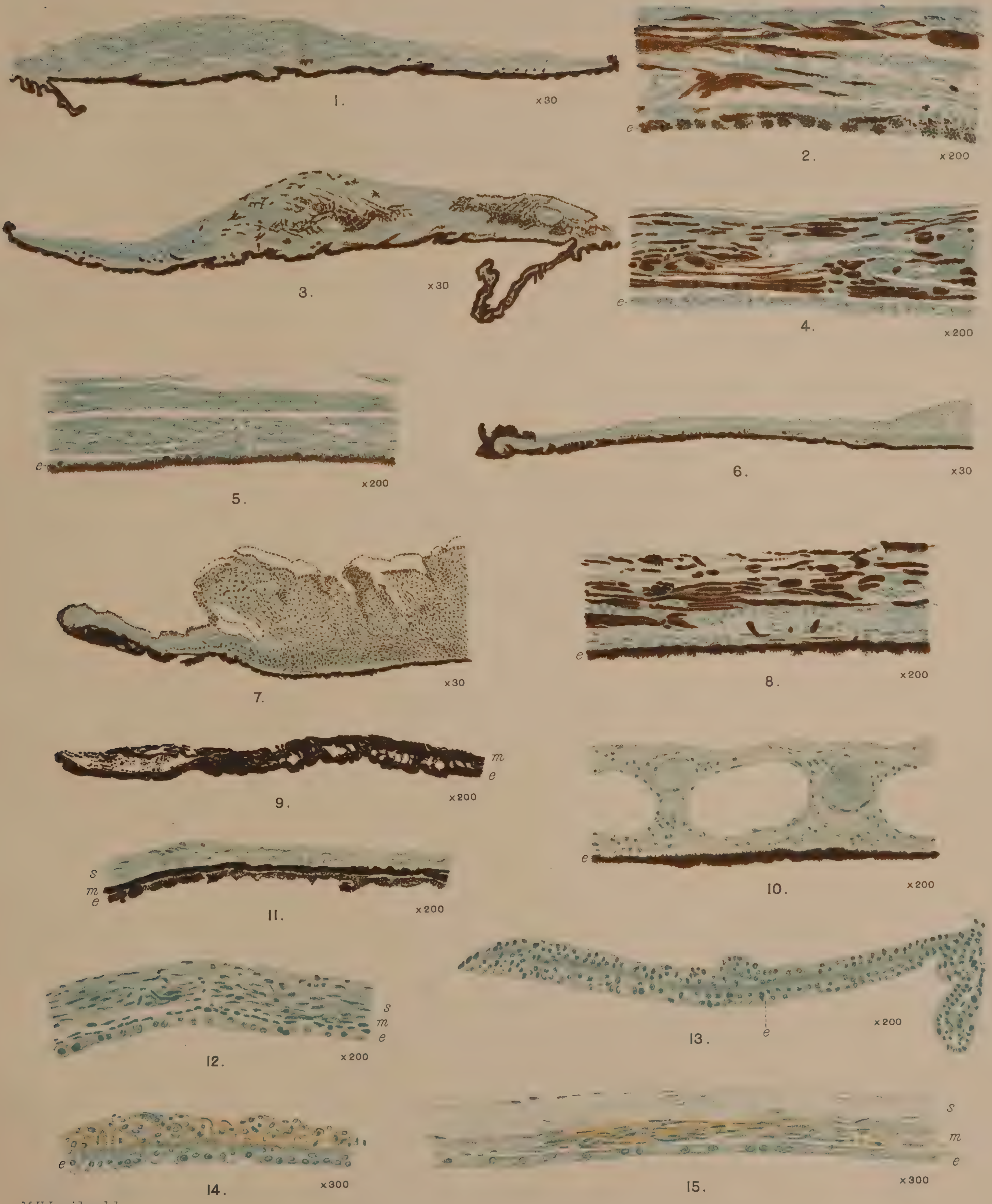


15.

Sections of Human Hair.



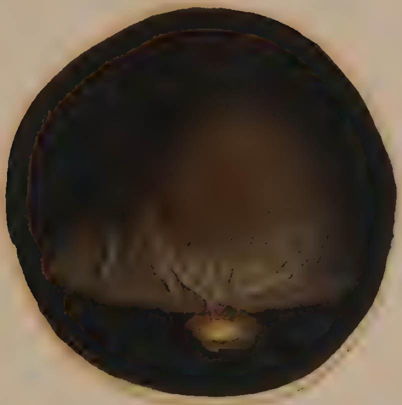
Diagrammatic Horizontal Section of Human Eye.



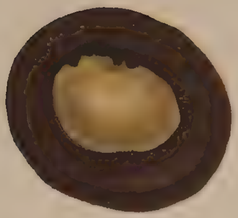
M.H.Lapidge del.

MICROSCOPIC DRAWINGS, IRIS AND CHOROID, NORMAL AND ALBINOTIC, IN VARIOUS ANIMALS.

PLATE I.



I.



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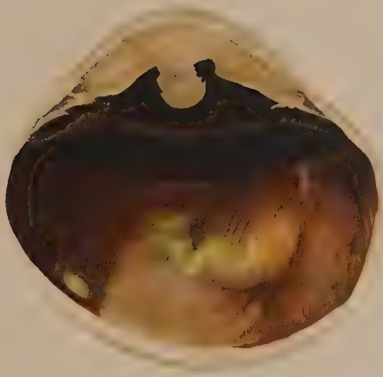

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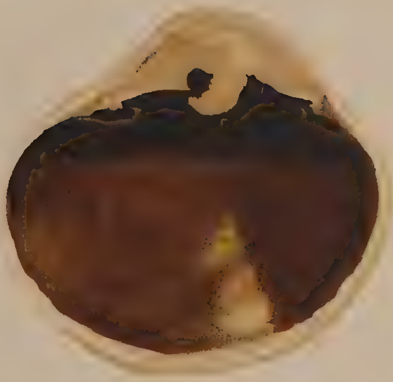

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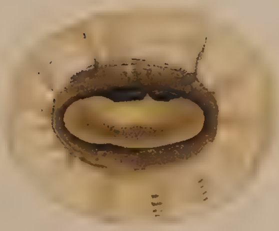

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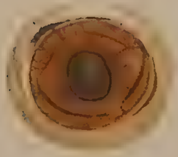

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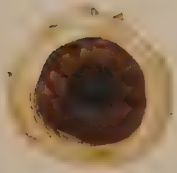
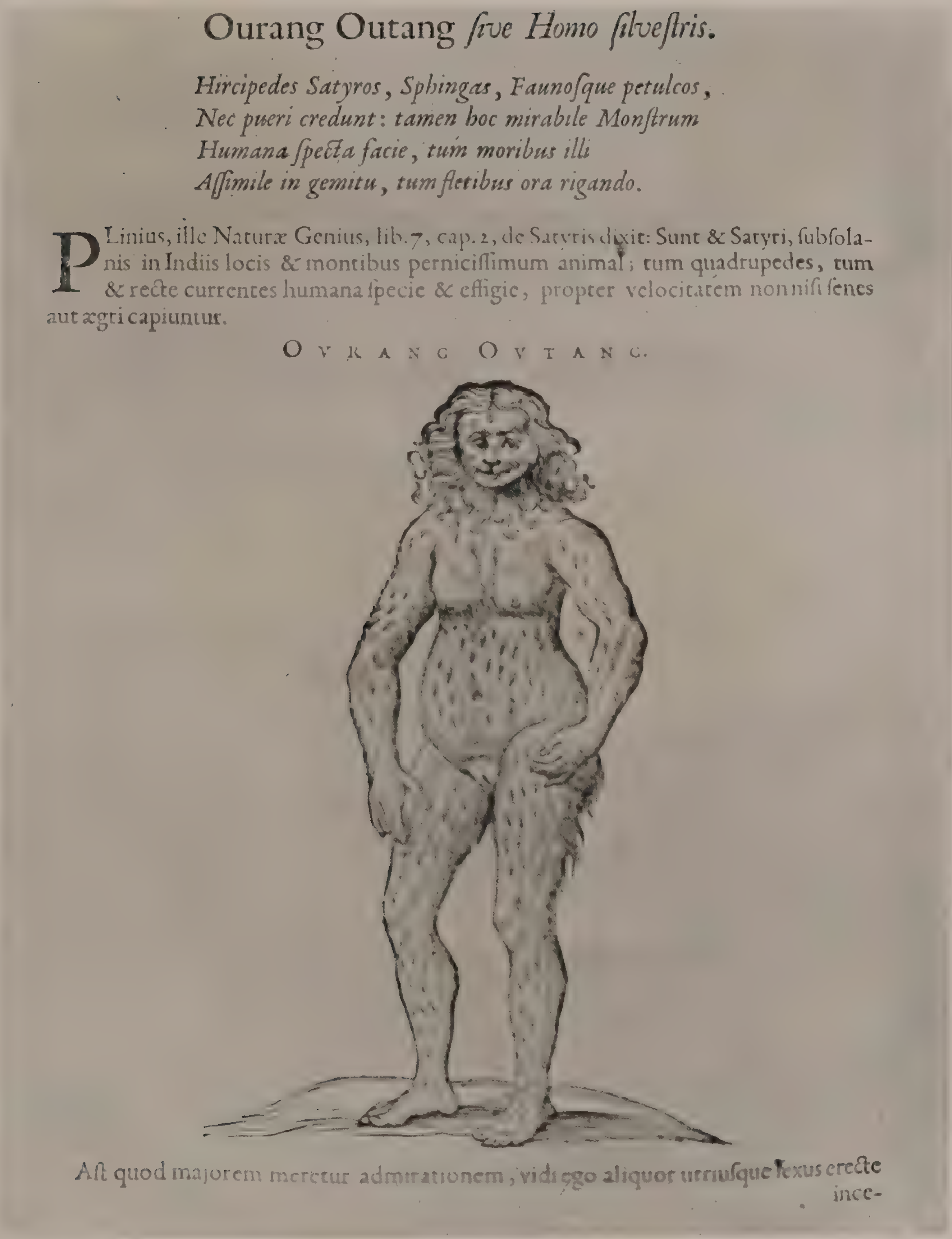


7.

Normal Horse.—1. Choroid posterior half, retina removed. 2. Normal Iris.
Wall-eyed Horse.—3-4. Antero-posterior section, crystalline lens and retina removed. 5. Iris, front view cornea removed.
Mountain Hare.—L. Variabilis. 6. Eye, January. 7. Eye, August, cornea removed.



Ourang Outang *ſive Homo ſilveſtris.*

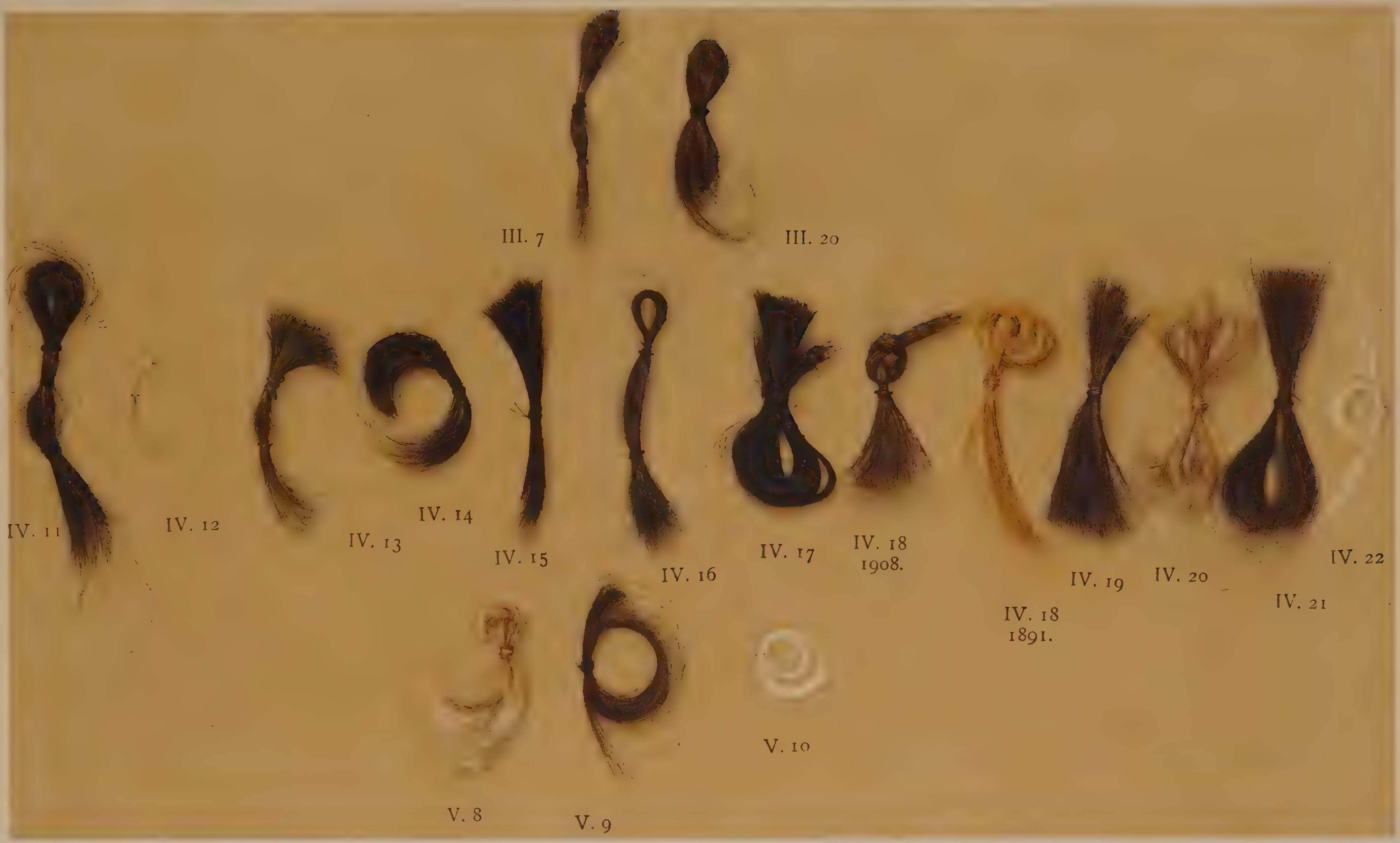
Hircipedes Satyros, Sphingas, Faunoſque petulcos,
Nec pueri credunt: tamen hoc mirabile Monſtrum
Humana ſpecta facie, tum moribus illi
Aſſimile in gemitu, tum fletibus ora rigando.

Plinius, ille Naturæ Genius, lib. 7, cap. 2, de Satyris dixit: Sunt & Satyri, ſubſolanis in Indiis locis & montibus perniciſſimum animal; tum quadrupedes, tum & recte currentes humana ſpecie & effigie, propter velocitatem non niſi ſenes aut ægri capiuntur.

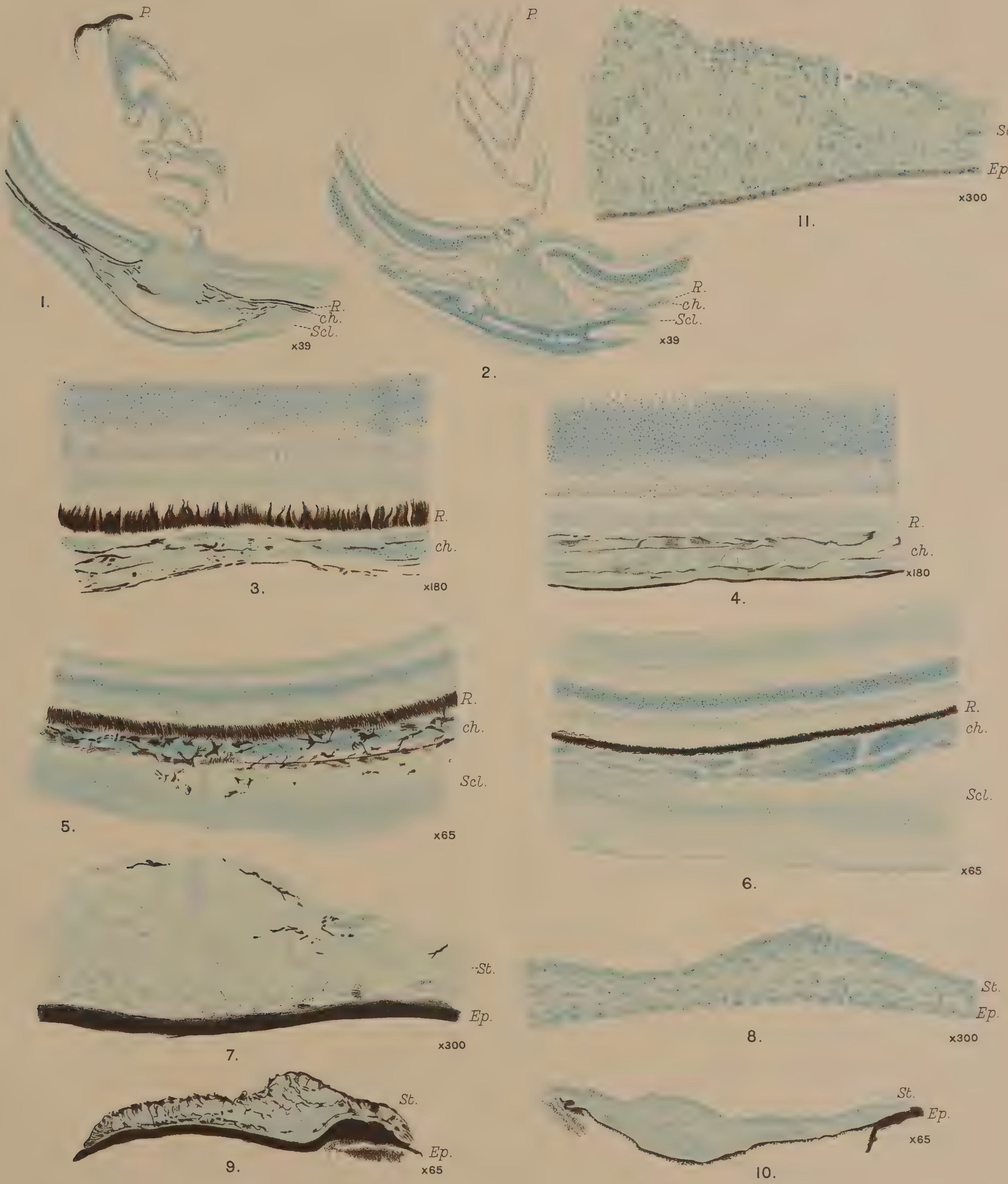
OVRANG OVTANG.

Aſt quod majorem meretur admirationem, vidi ego aliquot utriuſque ſexus erecte ince-

Bontius' Ourang Outang or *H. silvestris* of 1658, identified by Linnaeus in the first twelve editions of his *Systema* with the *H. nocturnus* or albino.



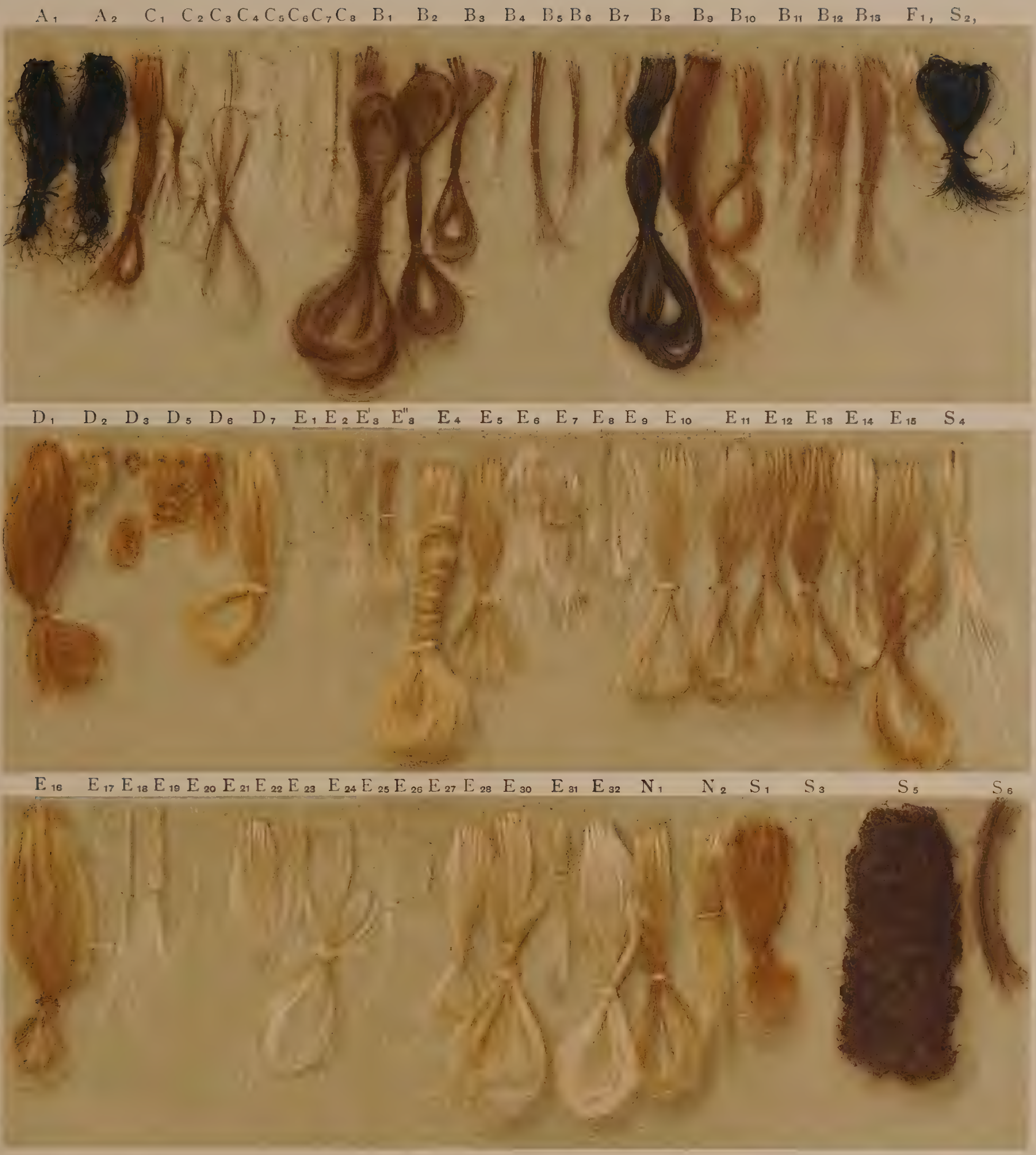
Hair Pedigree of an Albinotic Family (Fig. 535. C. H. Usher).



J.B.Souter del.

University Press Cambridge.

Microscopic Drawings, Iris, Choroid, Retina and Pecten, in normal and albinotic Birds.


A1 A2 C1 C2 C3 C4 C5 C6 C7 C8 B1 B2 B3 B4 B5 B6 B7 B8 B9 B10 B11 B12 B13 F1, S2,
D1 D2 D3 D5 D6 D7 E1 E2 E'3 E''3 E4 E5 E6 E7 E8 E9 E10 E11 E12 E13 E14 E15 S4
E16 E17 E18 E19 E20 E21 E22 E23 E24 E25 E26 E27 E28 E30 E31 E32 N1 N2 S1 S3 S5 S6

Samples of Albinotic, partially Albinotic and Normal Human Hair.

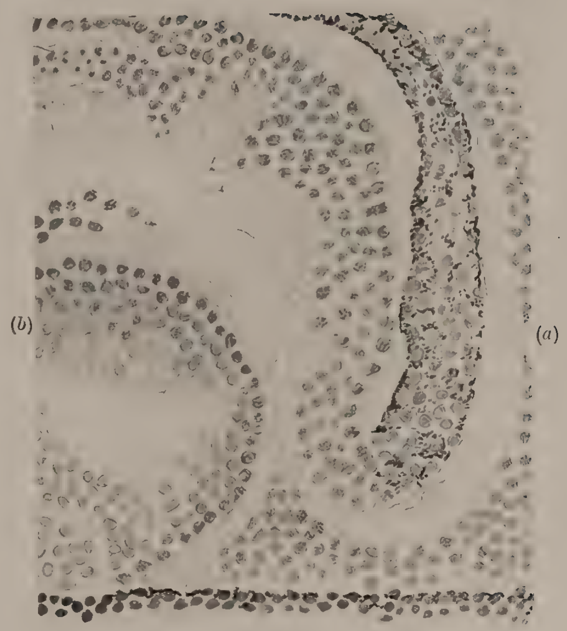


FIG. 1. SECTION OF EYE IN 4TH WEEK EMBRYO (10 MM. LONG).
(*a*) PIGMENT GRANULES IN PIGMENT LAYER OF RETINA.
(*b*) LENS. [DR LOW'S SECTION]

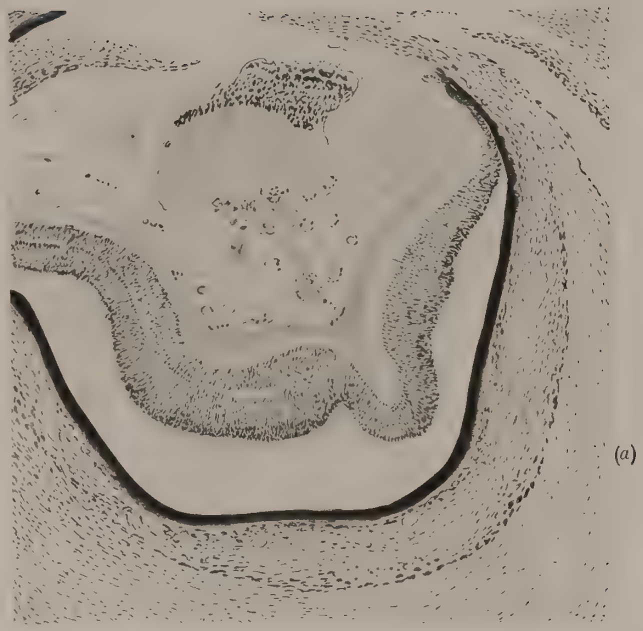


FIG. 2. SECTION OF EYE, 10TH WEEK FOETUS (28 MM. LONG).
(*a*) PIGMENT LAYER OF RETINA.
[DR LOW'S SECTION]

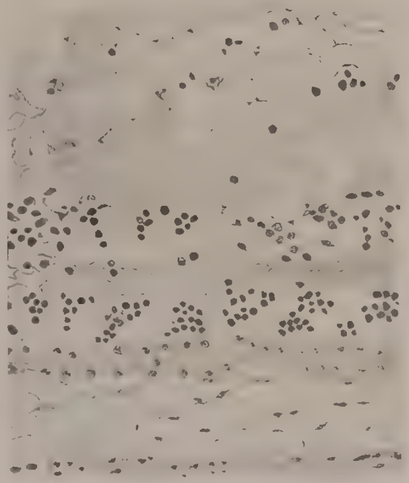


FIG. 3. SECTION OF RETINA OF ALBINO CHILD, WITH ABSENCE OF ALL PIGMENT.

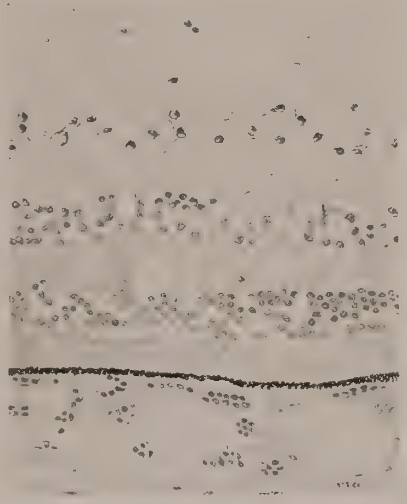


FIG. 4. SECTION OF RETINA OF NORMAL CHILD OF SAME AGE, SHOWING PIGMENT LAYER.

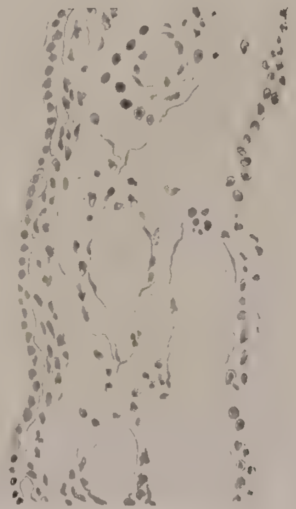


FIG. 5. SECTION OF IRIS OF ALBINO CHILD, WITH ABSENCE OF ALL PIGMENT.

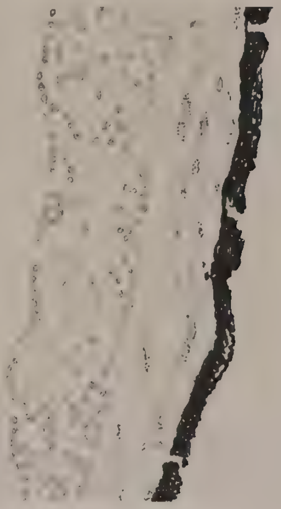
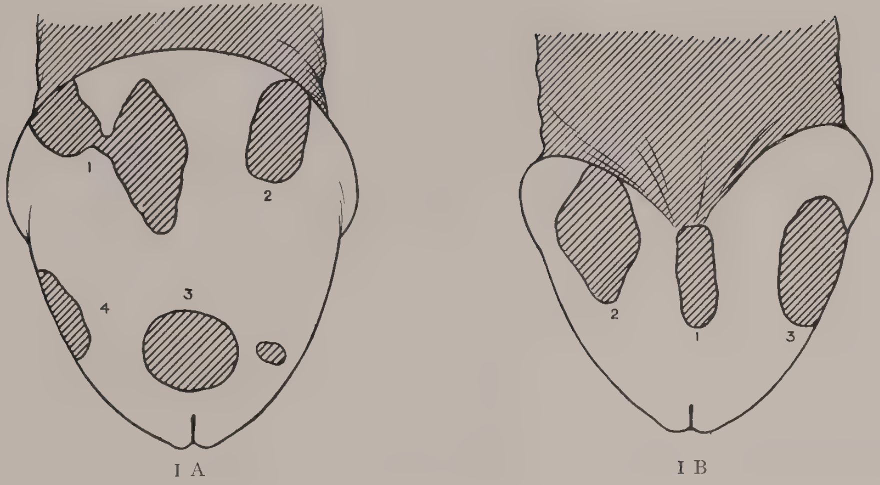
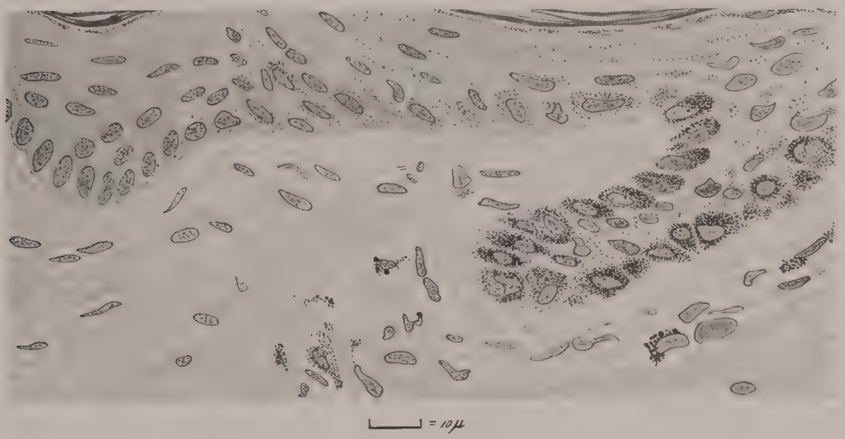


FIG. 6. SECTION OF IRIS FROM NORMAL CHILD OF SAME AGE.

REPRODUCED FROM ADLER AND MCINTOSH'S MEMOIR, *BIOMETRIKA* VOL. VII. BY KIND PERMISSION OF THE PROPRIETORS.



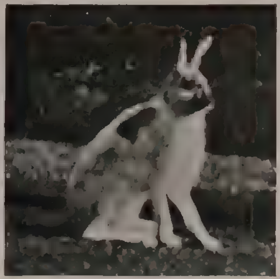
1 A AND 1 B. DORSAL AND VENTRAL ASPECTS, OF THE GLANS PENIS, SHOWING THE DISTRIBUTION OF THE PIGMENTED (SHADED) AREAS.



2. MICROSCOPIC SECTION THROUGH THE EDGE OF THE PIGMENTED AREA 3 ON THE DORSAL SURFACE OF THE GLANS. ON THE RIGHT-HAND SIDE OF THE SECTION DEEP PIGMENTATION INVOLVING THE BASAL CELLS AND TO A CERTAIN EXTENT THE SUPERFICIAL CELLS. PROCEEDING TOWARDS THE LEFT THE PIGMENT BECOMES MORE SPARSE ULTIMATELY TO VANISH ON THE EXTREME LEFT OF THE SECTION. IN THE SUBMUCOUS TISSUE SEVERAL CHROMATOPHORES ARE SEEN ON THE RIGHT-HAND SIDE OF THE SECTION.

IMPORTED NORWEGIAN MALE AND FEMALE VARIABLE HARES.

It is only possible to reproduce a selection of the photographs. The descriptions, pp. 421—6, are from the living hares, and their dates differ from those of the photographs.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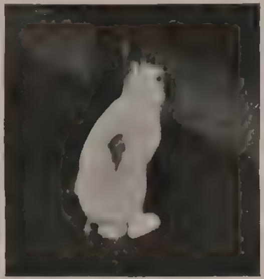
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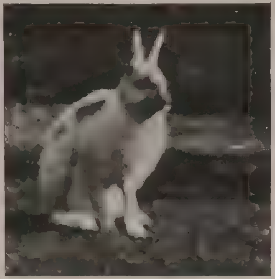
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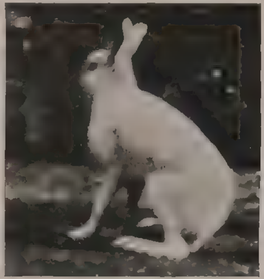
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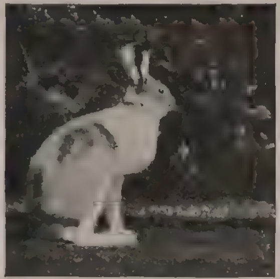
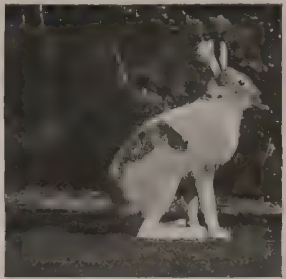

(5) 24/4/'10 ♂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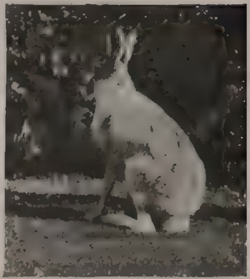
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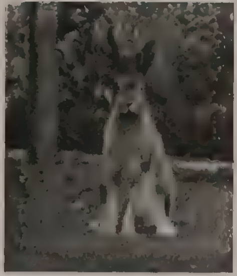
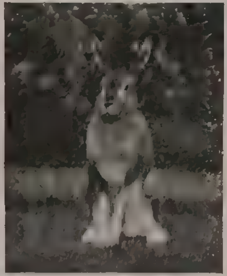
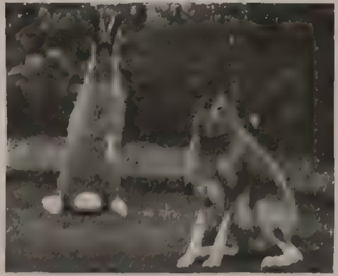
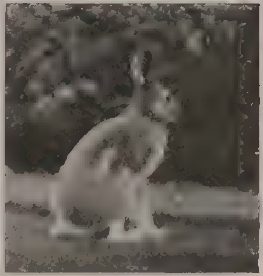

(13) 26/6/'10 ♂


(12) 30/5/'10 ♀


(11)^{b} ♂ '30/5/'10 ♀ (11)^{a}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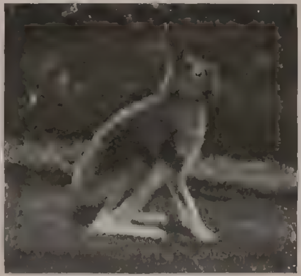
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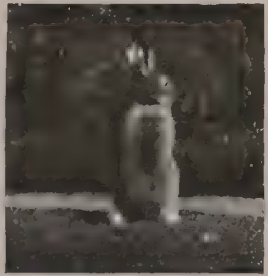
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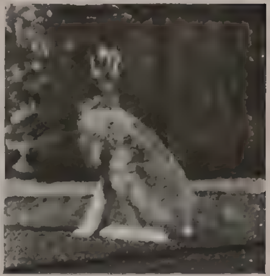
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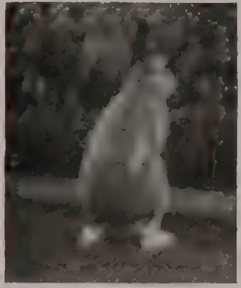
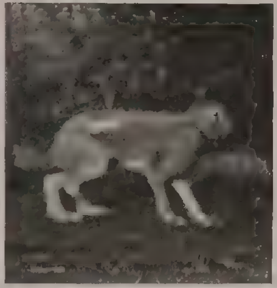
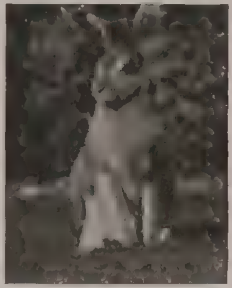
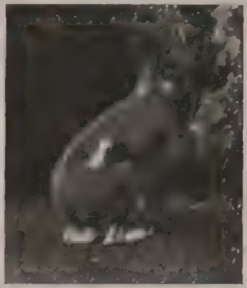
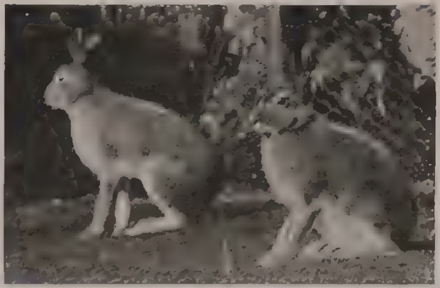
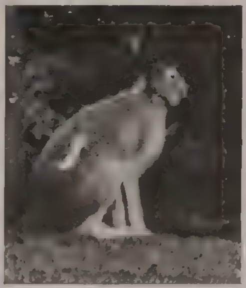

(14)^{b} 26/6/'10 ♂

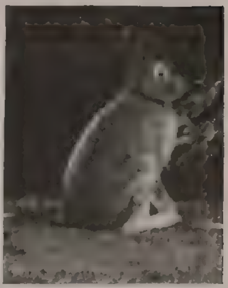

(15) 26/7/'10 ♂


(16) 22/8/'10 ♀


(17) 22/8/'10 ♂


(18)^{a} ♂ 22/8/'10 ♀ (18)^{b}


(20)^{a} 13/9/'10 ♂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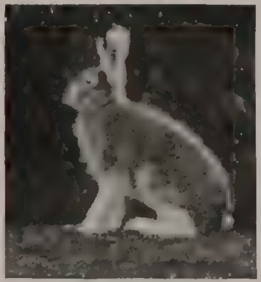
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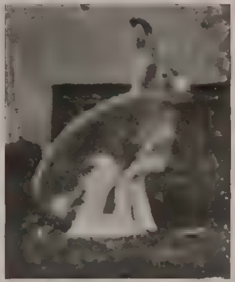
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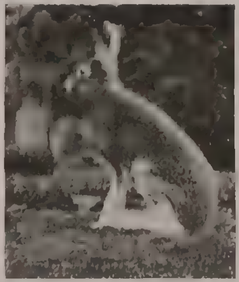
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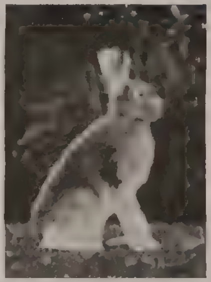
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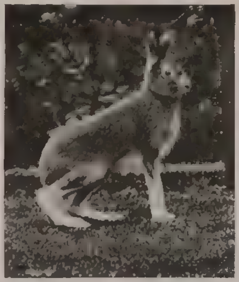
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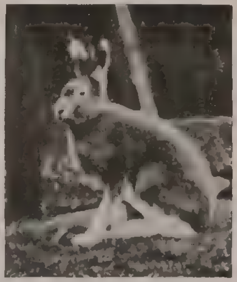
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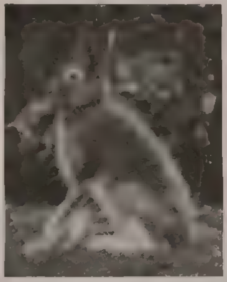
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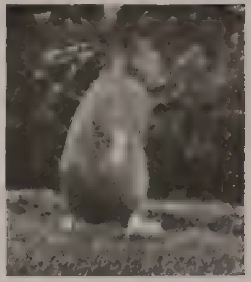
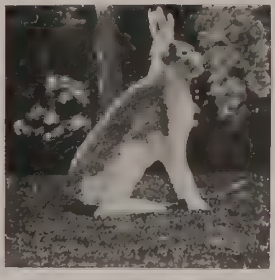
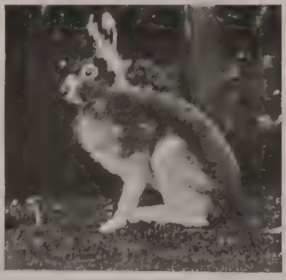

(21)^{a} 13/9/'10 ♂


(28) 2/11/'10 ♀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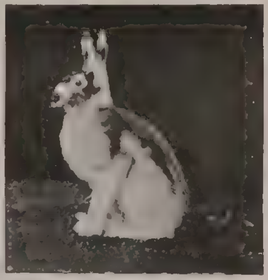
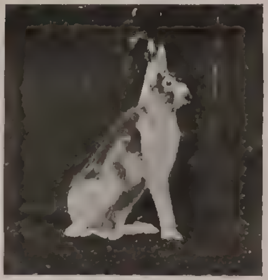

(30) 9/11/'10 ♀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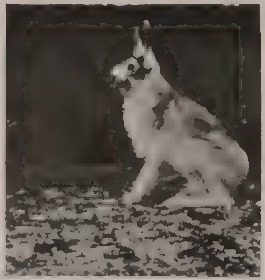
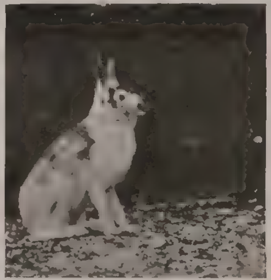
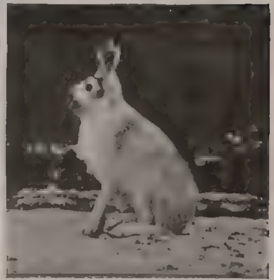
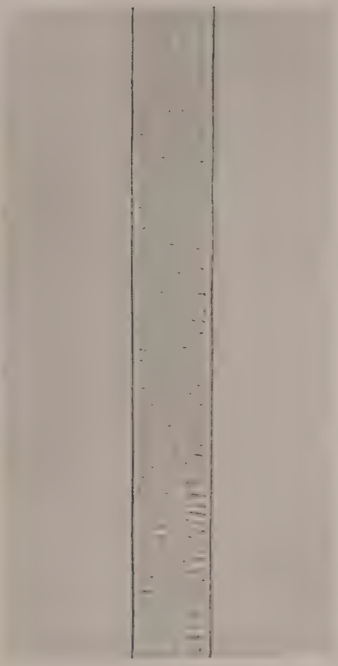
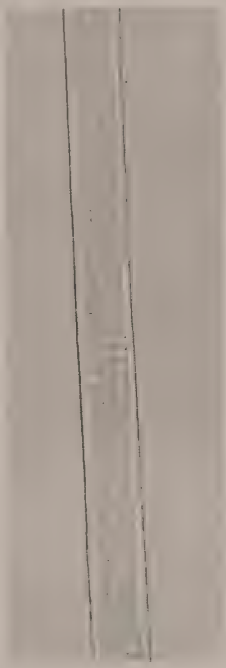

(32) 16/11/'10 ♀

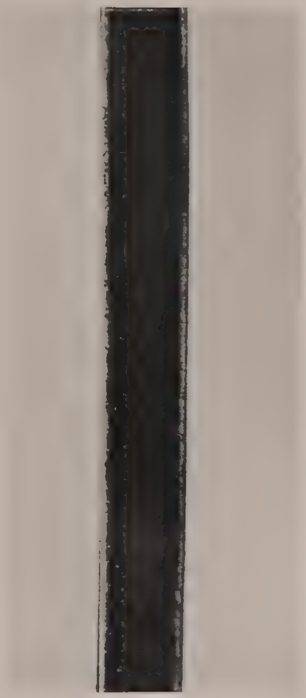

(34) 16/11/'10 ♀

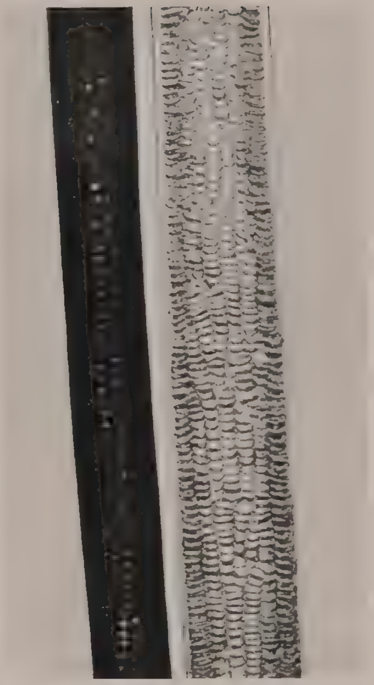

(36) 23/11/'10 ♀

Hairs of *Lepus variabilis*, microphotographs by Mr C. H. O'Donoghue.


(1)


(2)


(3)


(4)

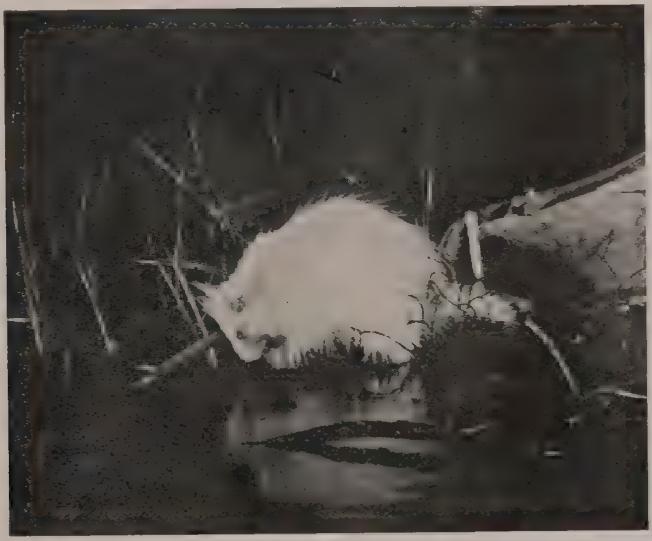
Hair of winter coat, total absence of pigment.

Winter coat, nearer to tip of hair, no pigment.

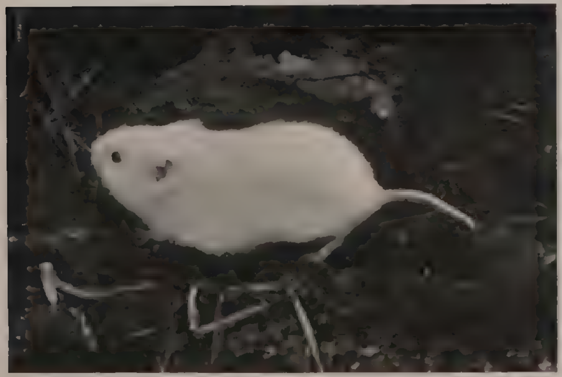
White hairs of p. 450 (*d*).

Hair of summer coat, densely packed with pigment granules. p. 451 (*k*).

Banded hair, well pigmented frustrum nearer tip on left, frustrum of same hair with diffused pigment only on right. p. 450 (*d*).


(5)

Mr George Shiras's albino porcupine, eating moss. Flashlight photograph, *National Geographical Magazine*, Vol. XXII. p. 574, 1911.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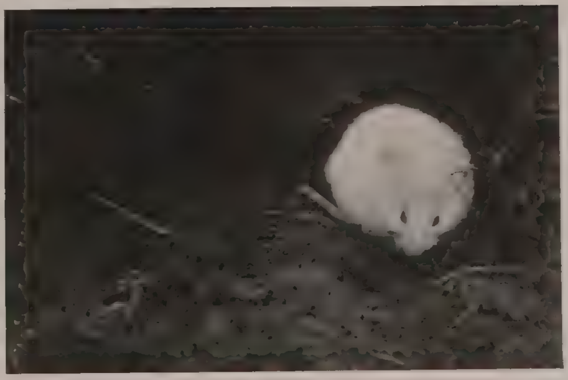
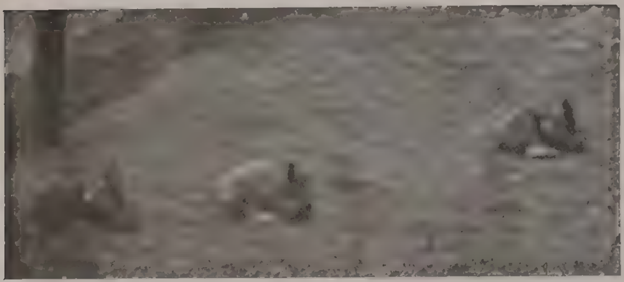
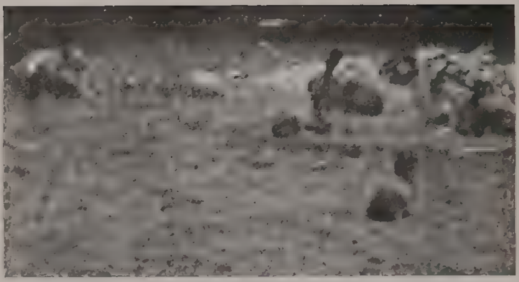

(7)

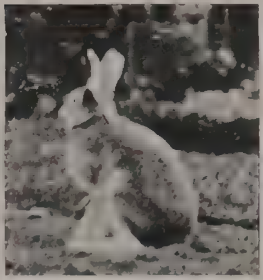
Albino *Mus agrestis* from photographs most kindly sent to K. Pearson by Mr Douglas English. Red "rather metallic" looking eyes, no trace of yellow in fur.

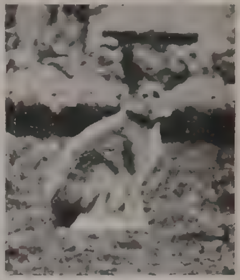
ABERDEEN-BRED NORWEGIAN

An asterisk (✻) marks the imported Norwegian mother.


(1) 26/6/10, Leverets


(2) 14/8/10, Leverets


(3) 12/10/10✻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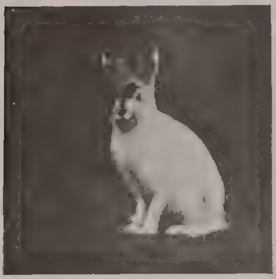
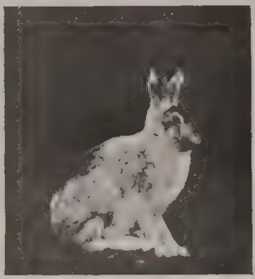

(22) 7/12/10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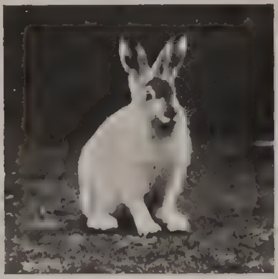
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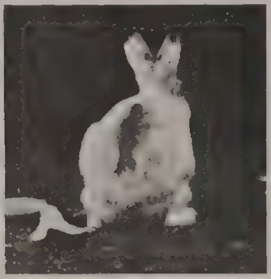
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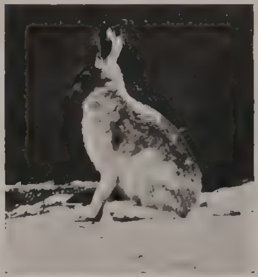
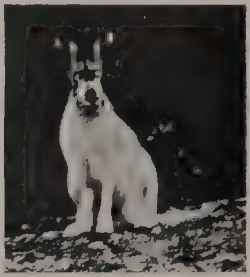
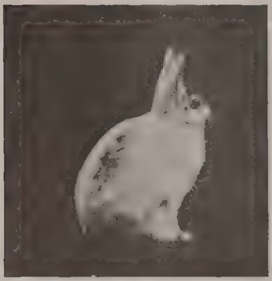

(18) 23/11/10


(17) 16/11/10✻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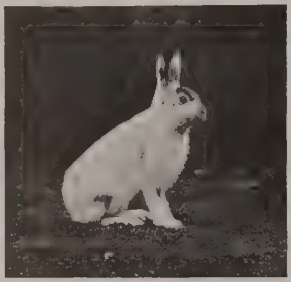
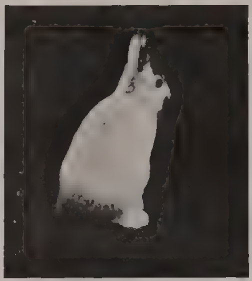
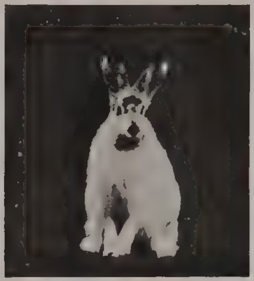
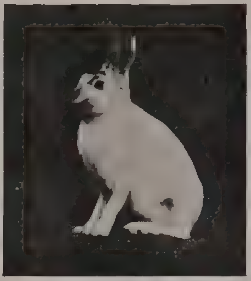

(24) 14/12/10


(25) 14/12/10


(26) 14/12/10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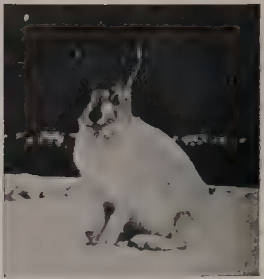
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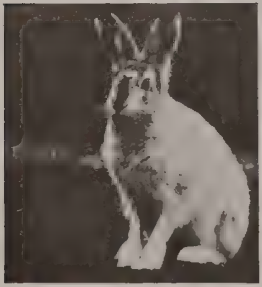
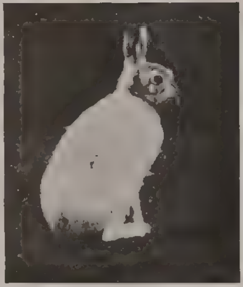

(46) 1/4/11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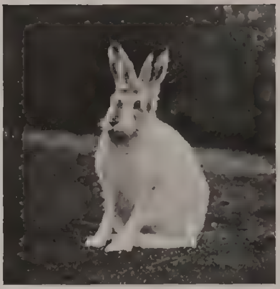
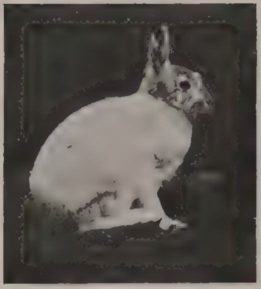

(44) 28/3/11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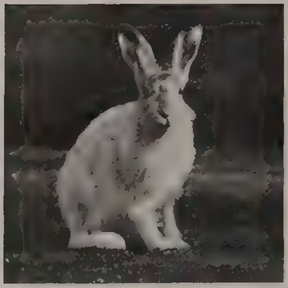
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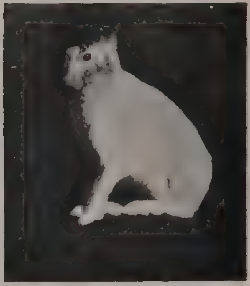
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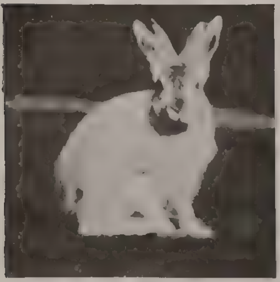
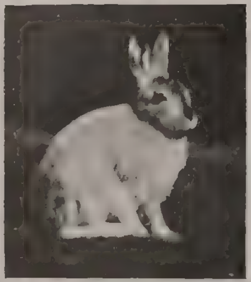

(47) 5/4/11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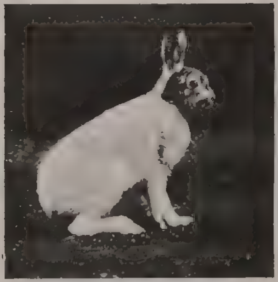
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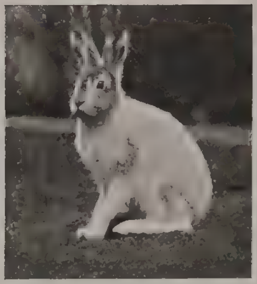
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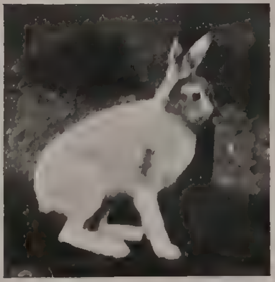
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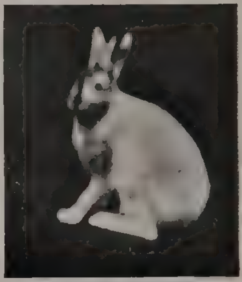
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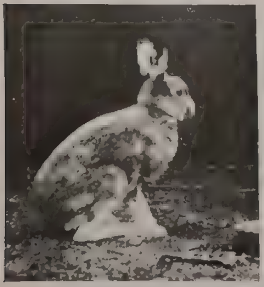
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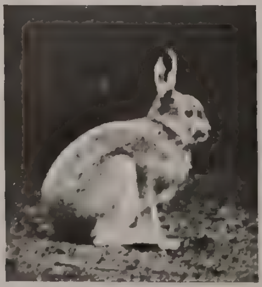
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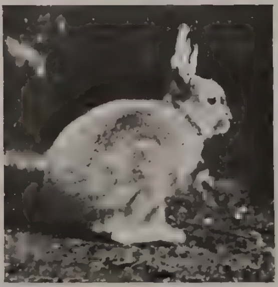
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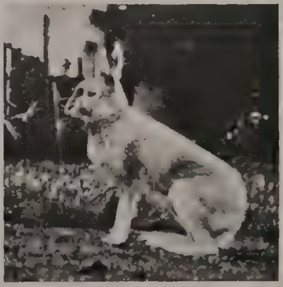
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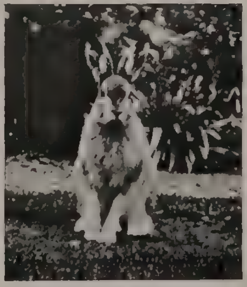
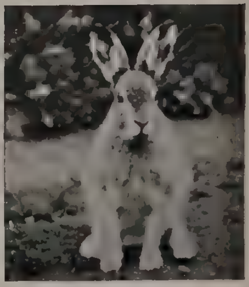
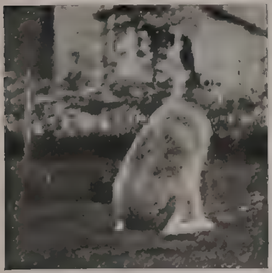

(66) 19/5/11

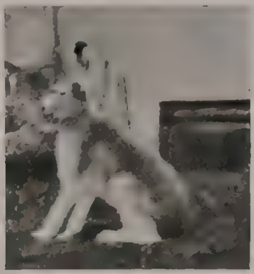

(65) 19/5/11

The reader will find some

VARIABLE HARES.

The Aberdeen-bred male hare is not so marked.


(5) 26/10/10*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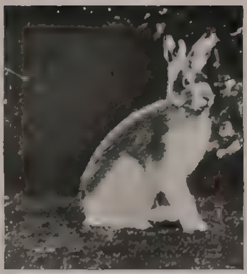
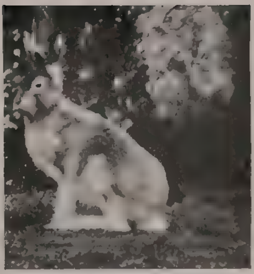
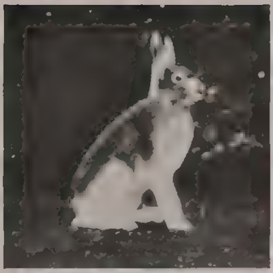
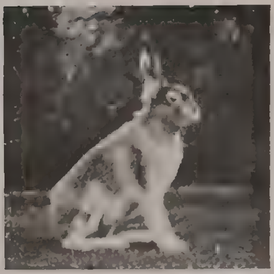

(7) 2/11/10*


(8) 2/11/10


(9) 2/11/10*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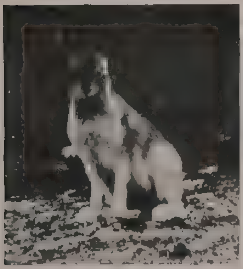
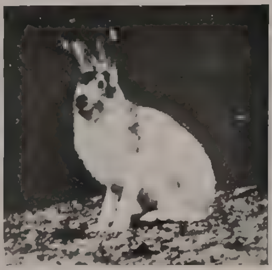

(16) 16/11/10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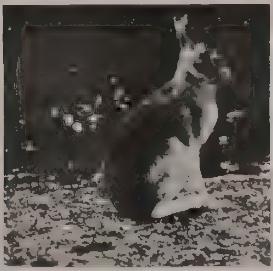
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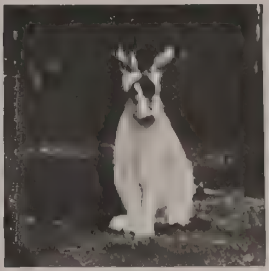
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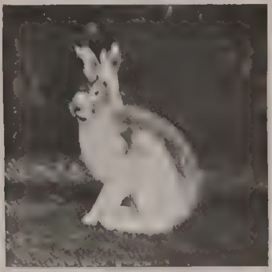
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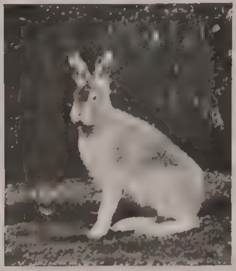
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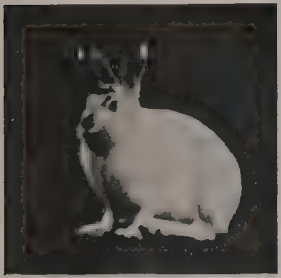
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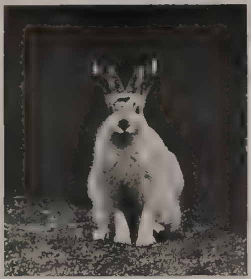
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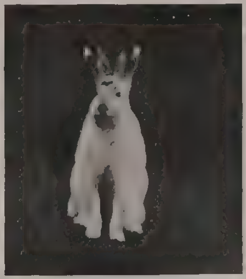
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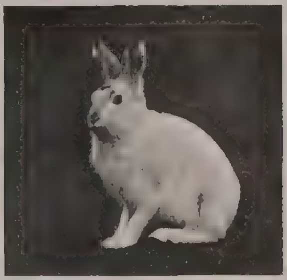
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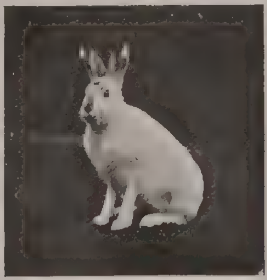
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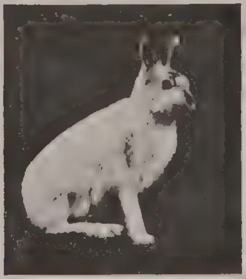
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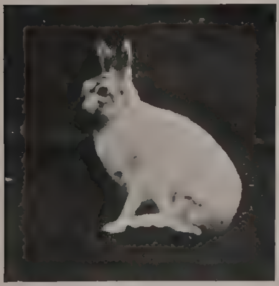
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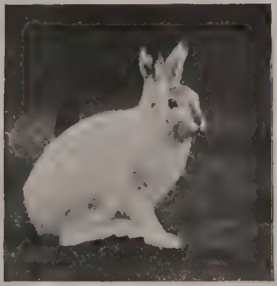
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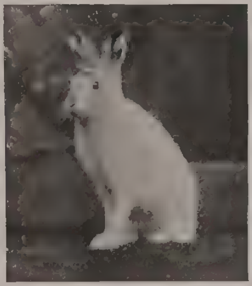
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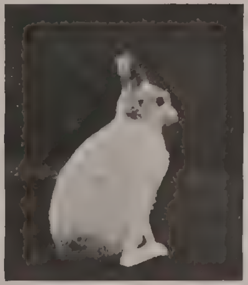
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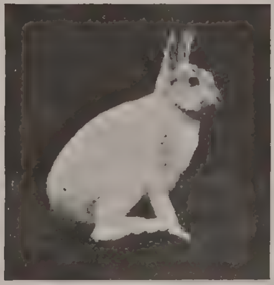
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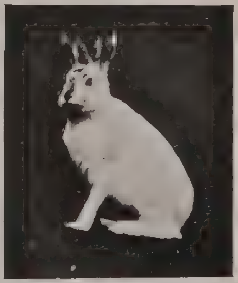
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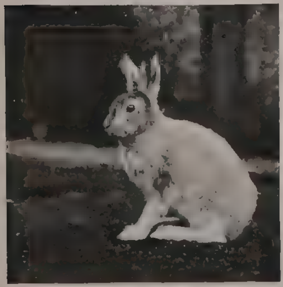
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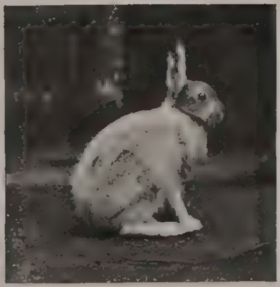
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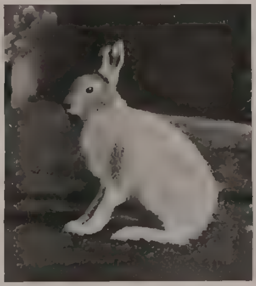
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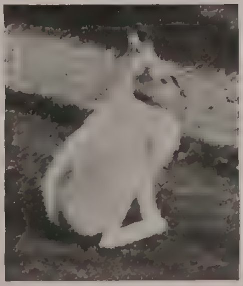
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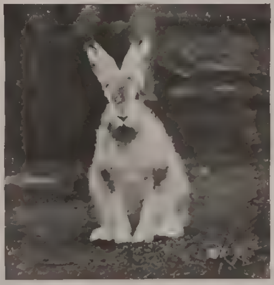
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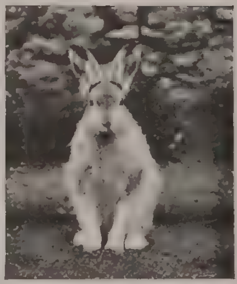
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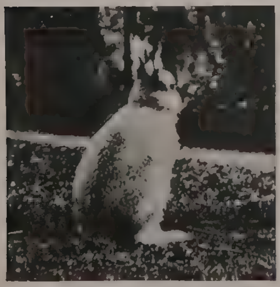
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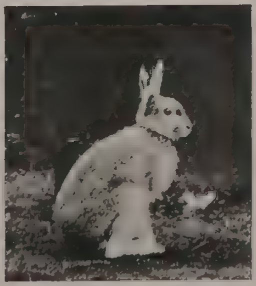
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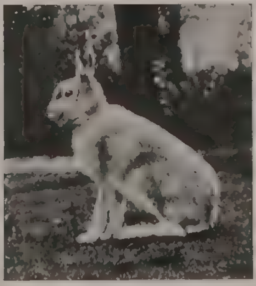
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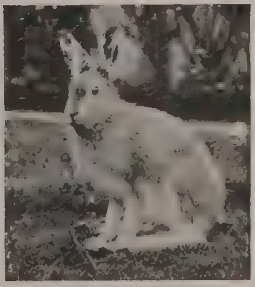
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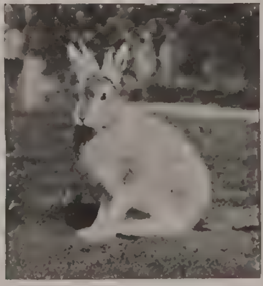
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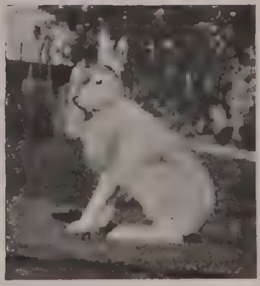
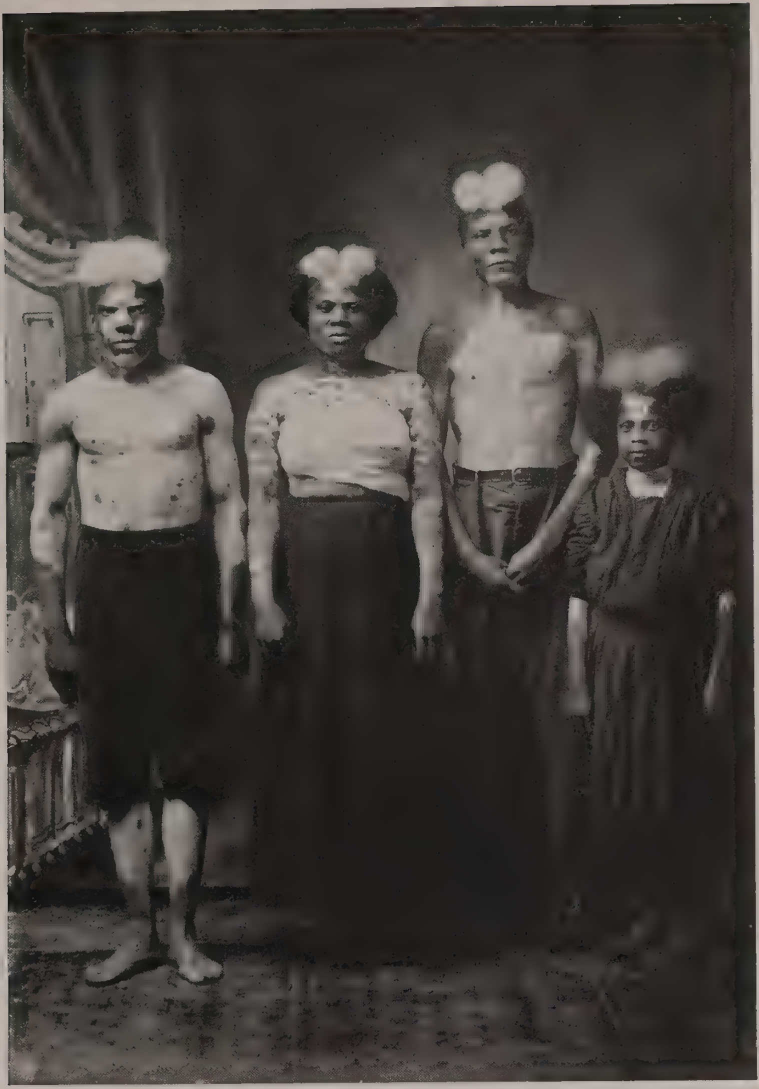
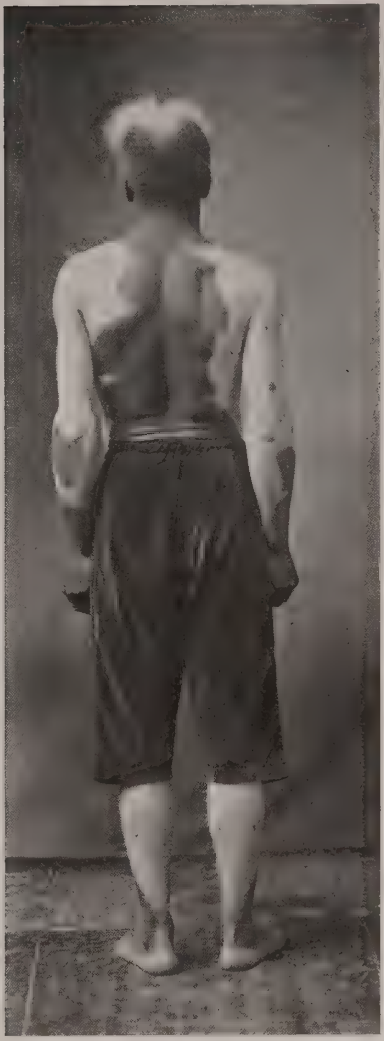

(59) 6/5/11

assistance from the use of a lens.



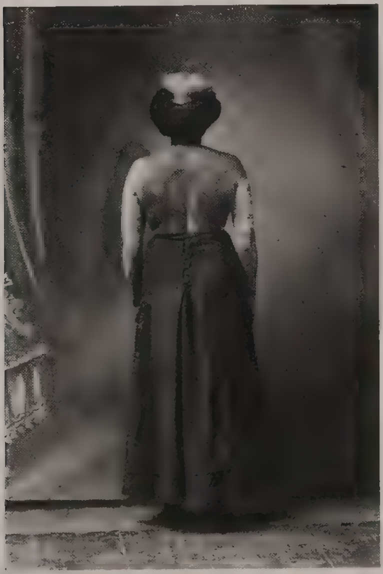
(1)

Extra Pedigrees X. Jim D. X. iv. 2, Mrs Eliza D. X. iii. 1, Robert D. X. iv. 3, and Lillie D. X. iv. 4, from left to right. Mother and three children. Father a mulatto.



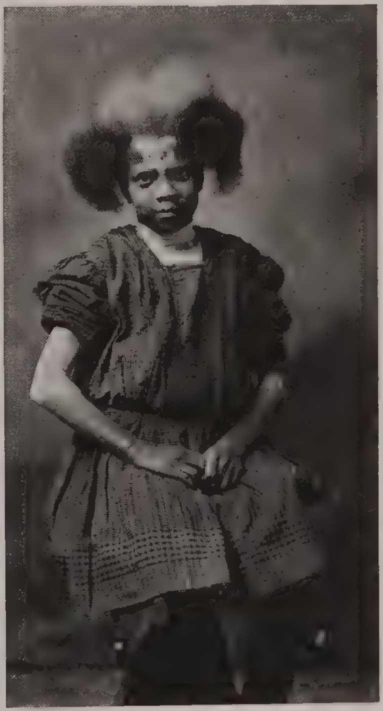
(2)

Jim D. Extra Pedigrees X. iv. 2. Dark pigment, Robert has light pigment.



(3)

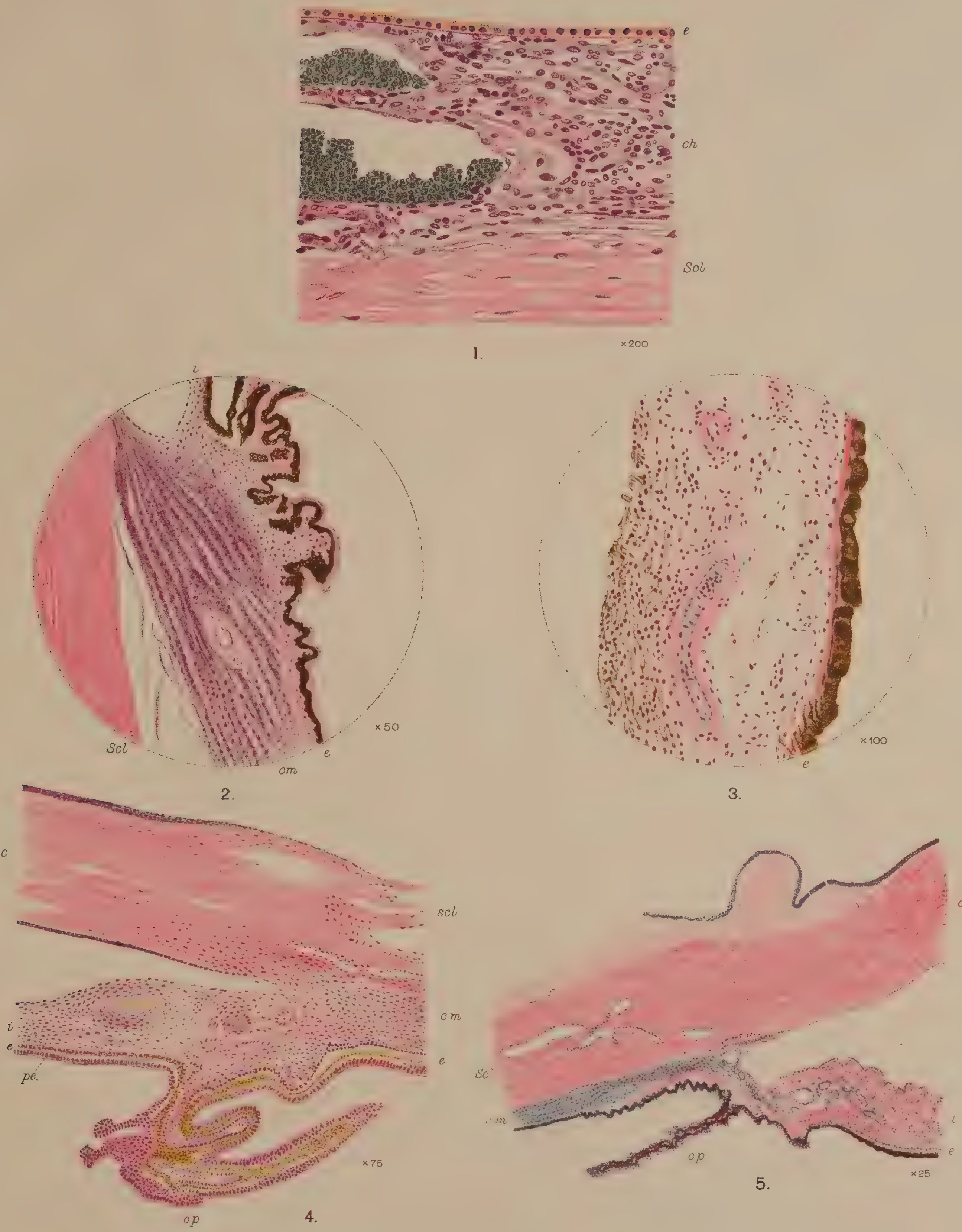
Mrs Eliza D. Extra Pedigrees X. iii. 1.



(4)

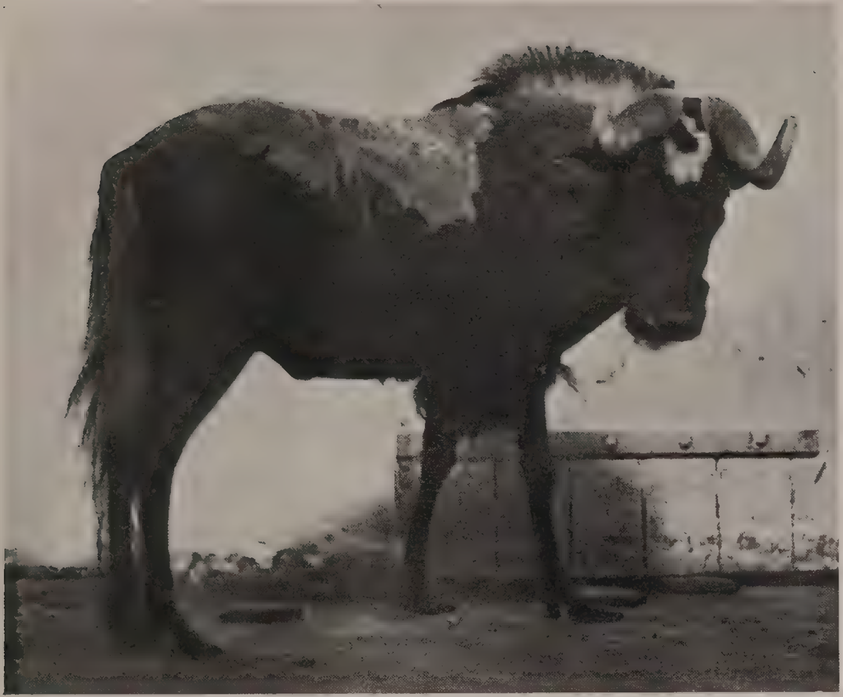
Lillie D. Extra Pedigrees X. iv. 4. Dark pigment.

Simpson and Castle's Piebald Negro Family. Blocks kindly lent by the Authors and by the Proprietors of *The American Naturalist*. See Extra Pedigrees. Fig. X.

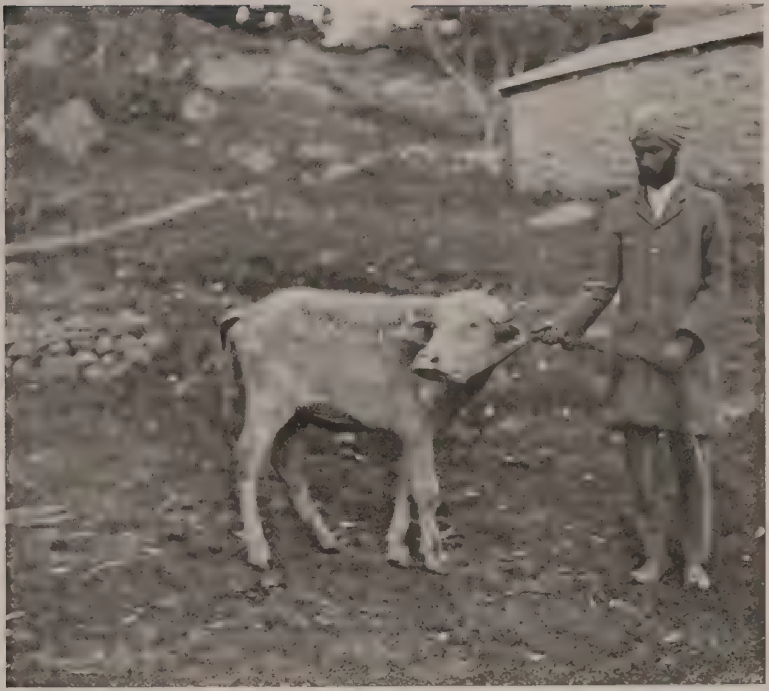


M.H.Lapidge, del. E.Wilson, Cambridge

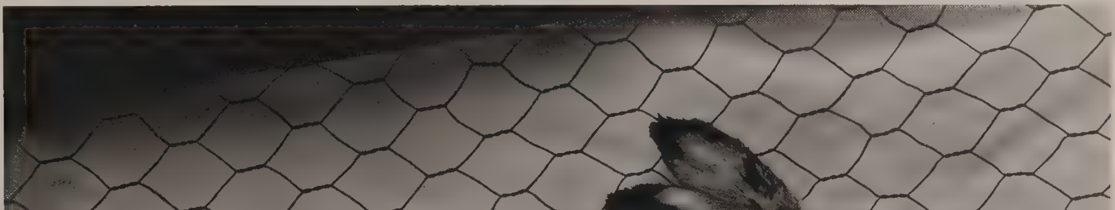
FIGS. 1.2.3. SECTIONS OF ALBINO NEGRO'S EYE. FIGS. 4 & 5 SECTIONS OF ALBINO PEKINESE DOGS' EYES. FOR DESCRIPTION: SEE P. 403 OF TEXT.



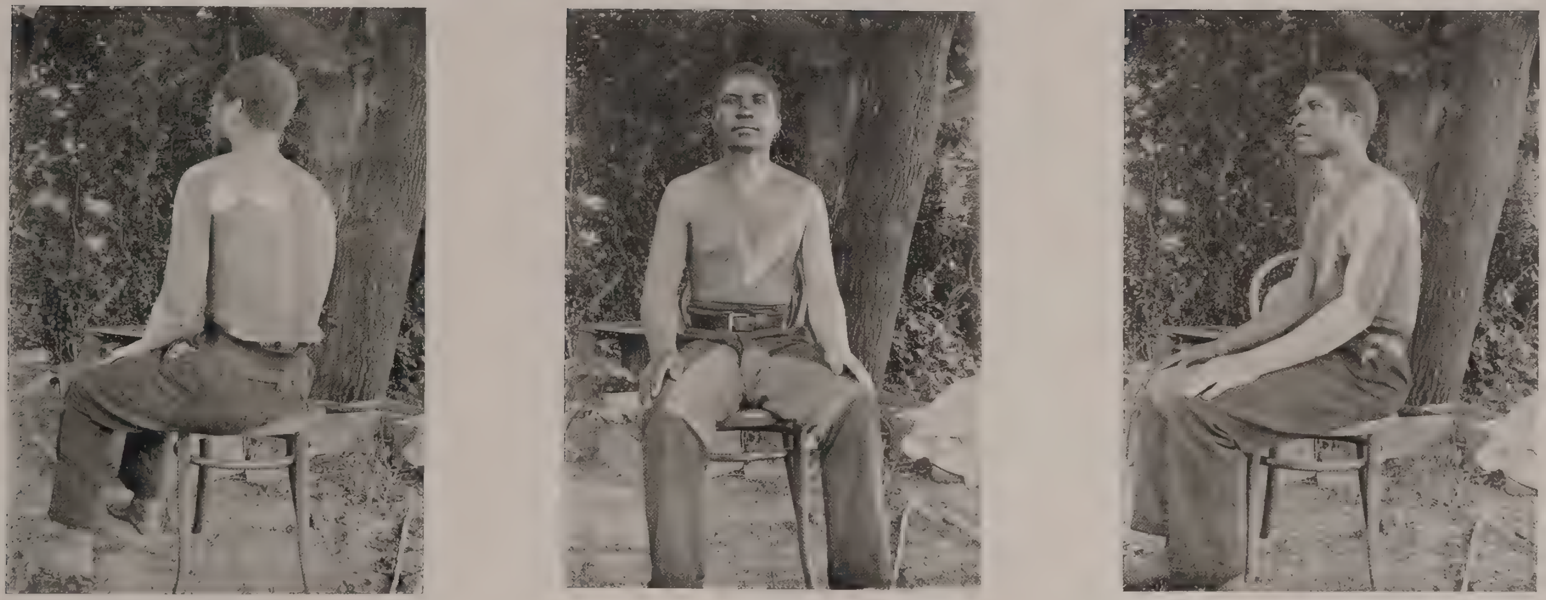
1. Partial Albinism in a *Counochaetes Gnu*, which has a remarkable white flare on the forehead, from a photograph sent by Dr Graham Renshaw.



2. Albino Buffalo Calf, from a photograph sent by Major W. F. Harvey, I.M.S., Pasteur Institute, Kasauli.

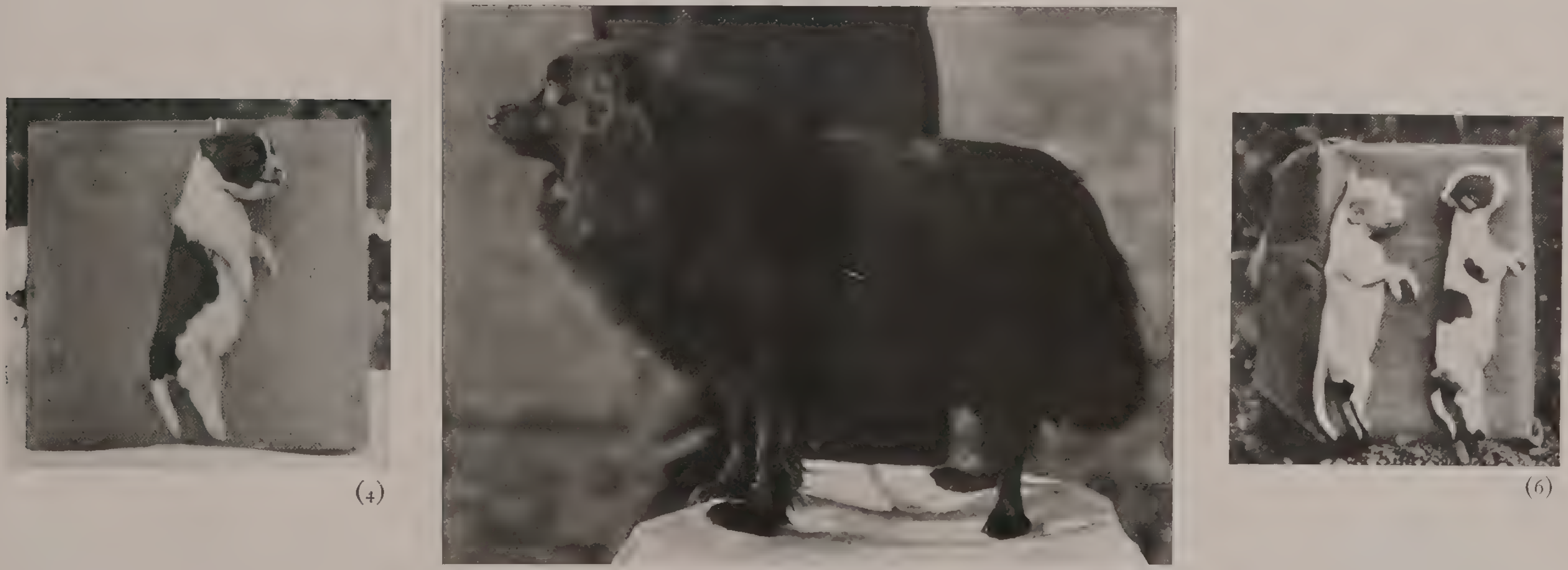


3. Adult female Norwegian Hare died and photographed November 25, 1910. The illustration shows very clearly the long hair on the "crown patch" remaining from the summer coat: see *Text*, p. 425.



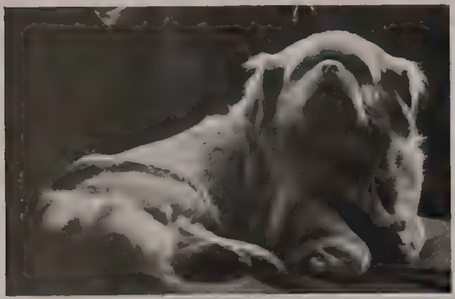
(1) (2) (3)

Illustrations of V. 5, extra Pedigrees Fig. W, one of the three piebalds occurring in Dr N. M. Macfarlane's case of the Basutoland family with 15 complete Albinos.

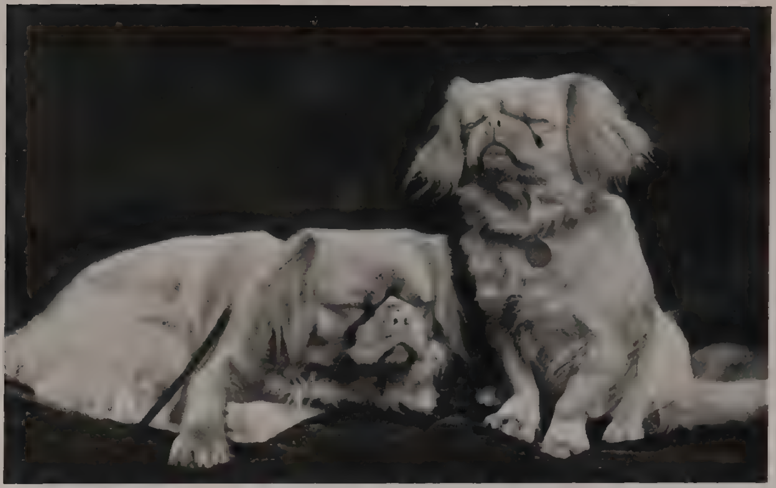


(4) (5) (6)

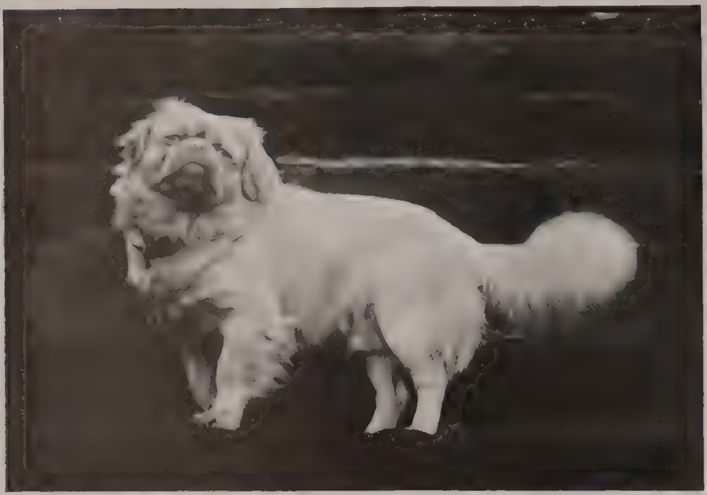
Illustrations of piebaldism occurring in stock with albinotic ancestry in Dogs. (5) is the Pomeranian bitch Olga, ancestry pure black for many generations. Crossed with the white albino Pekinese Dondo the result is a short-nosed dog the Pompek, which is usually pure black, but may have a little white on chest (see Plate χ). (4) and (6) represent offspring of Pompek ♂ × Dondo ♀; the offspring may be whole black or piebald, they have the short muzzles of the original Dondo ancestry.


(1)

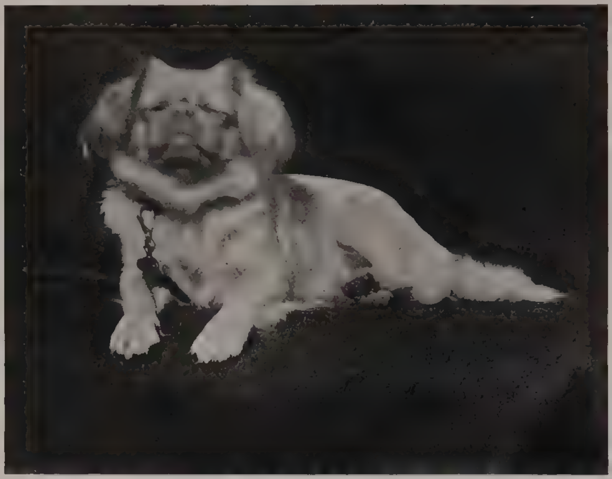
VII. 17. ♀ Tong I (Foundation Stock).


(2)

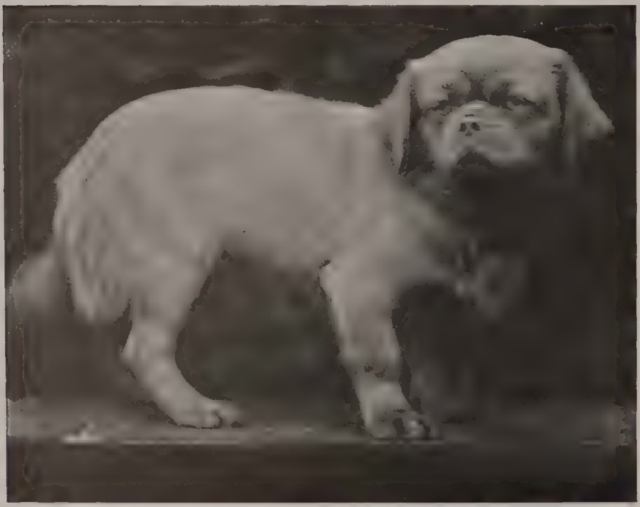
XI. 31. ♂ Wee Ling. XI. 33. ♀ Wee Tong, 2 years.


(3)

XI. 31. ♂ Wee Ling, 2 years.


(4)

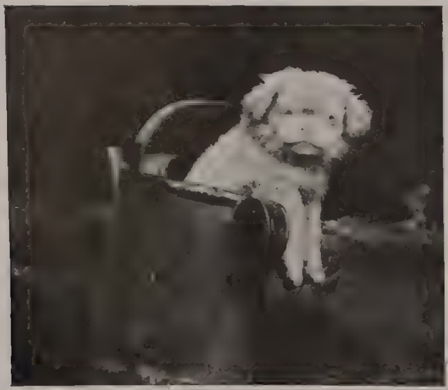
XI. 33. ♀ Wee Tong, 2 years.


(5)

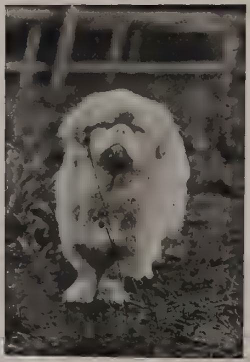
XI. 26. ♀ Mairi Bhan, aged 9 months.

(6)

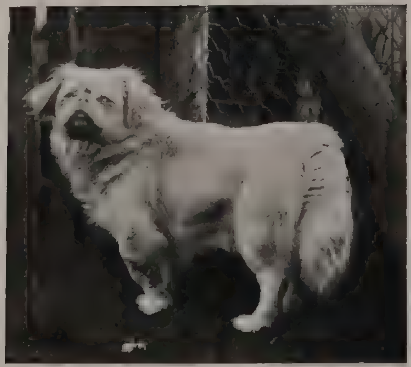
XI. 31. ♂ Wee Ling, aged 2 years.


(7)

XIII. 6. ♂ Cyclops.

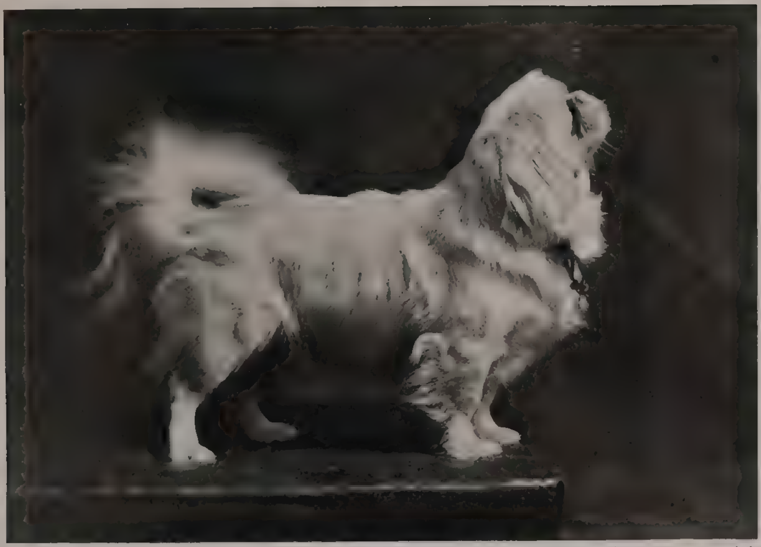

(8)

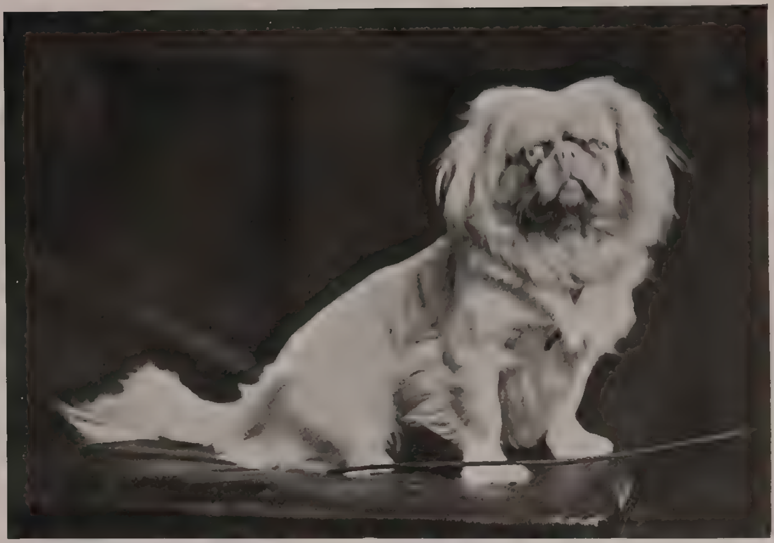
XII. 17. ♂ Donald Ban ("Idiot").

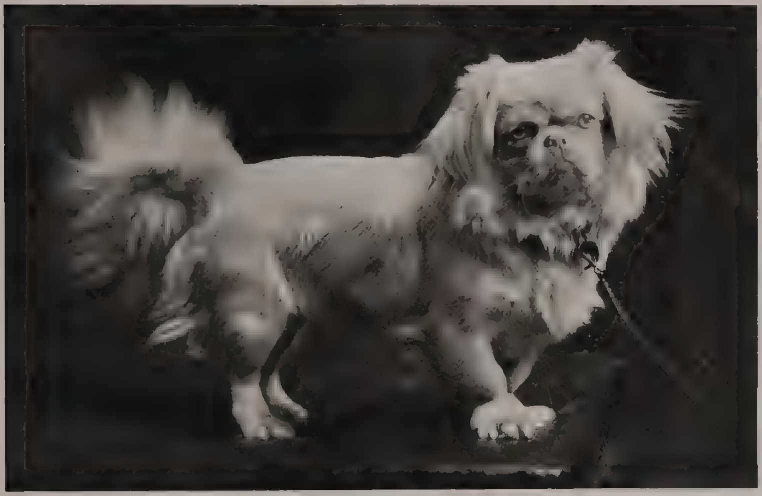

(9)

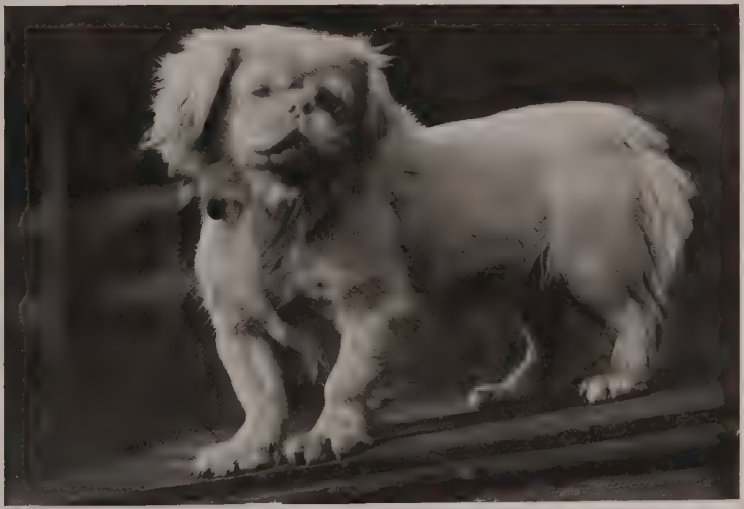
X. 20. ♀ Spook (Foundation Stock).

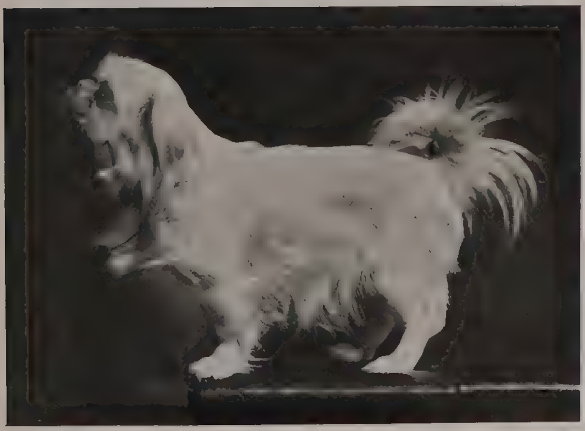
(1)—(18) ALBINO PEKINESE SPANIELS = DONDOS.

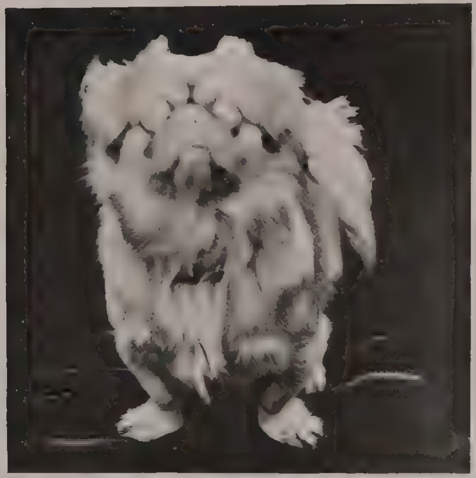

X. 9. ♂ JACK (FOUNDATION STOCK). (10)*

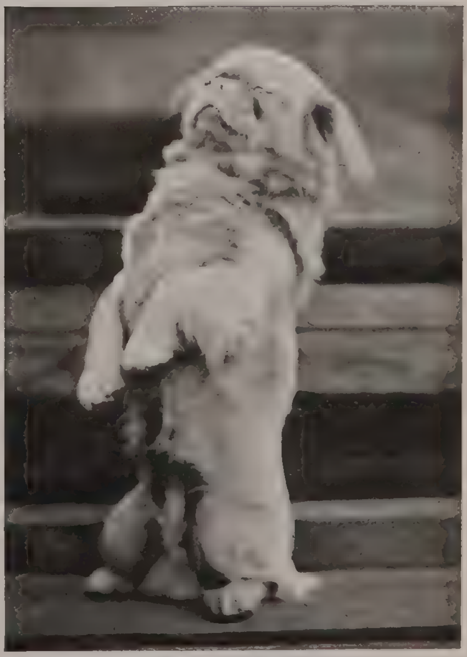

X. 9. ♂ JACK (FOUNDATION STOCK). (11)*

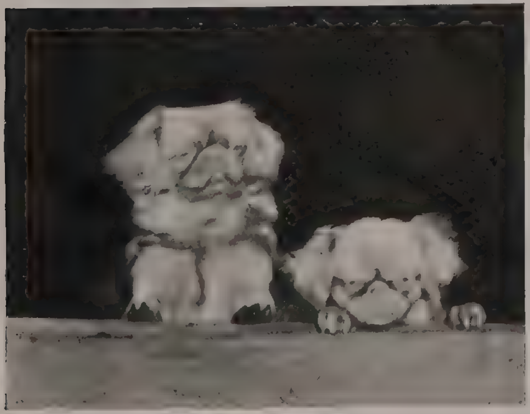

XI. 13. ♀ PATTY. (12)

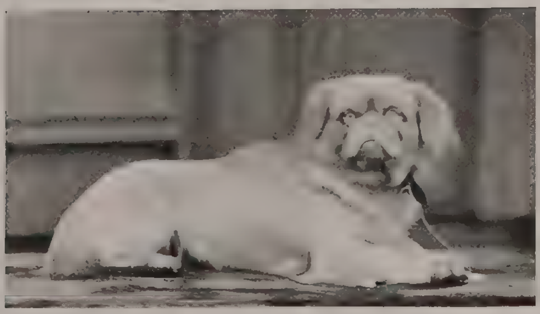

XI. 13. ♂ HAMISH. (13)


X. 10. ♀ JILL (FOUNDATION STOCK). (14)*

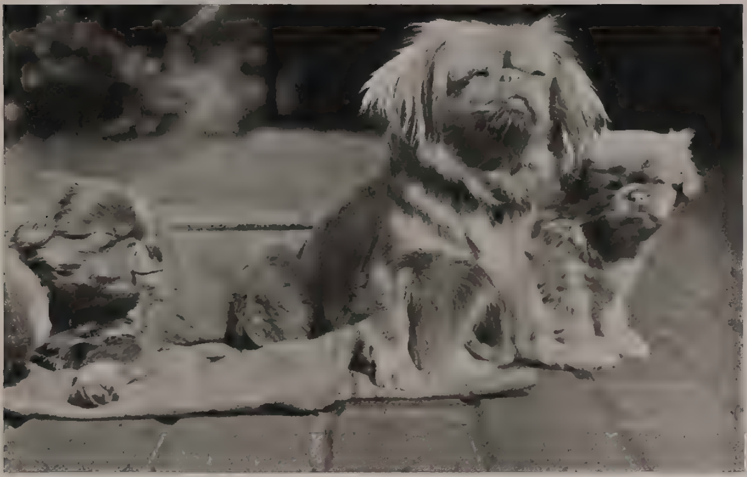

XI. 6. ♂ WANG. (17)


XI. 27. ♂ IAN BAN. (16)

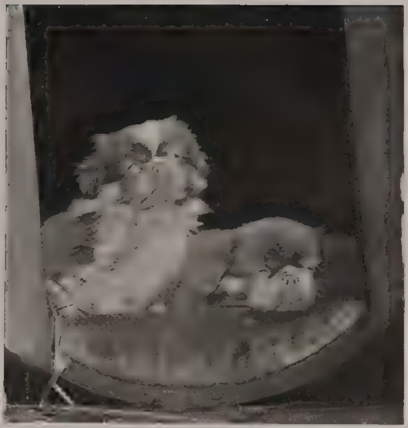

X. 9 AND X. 10. JACK AND JILL AS PUPPIES, 12 MONTHS OLD. (15)


XI. 27. ♂ IAN BAN. (18)

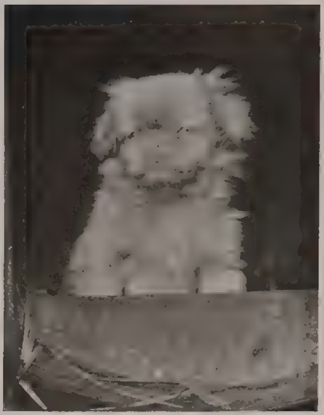
* (10), (11) and (14) are at age 4 years.



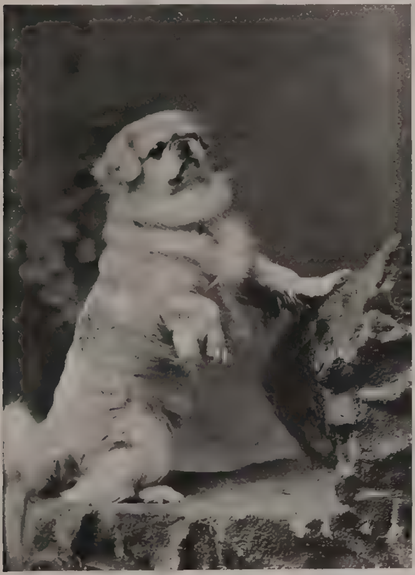
X. 10. ♀ Jill, and her coloured pups, ♂ Fe, XI. 9. and ♂ Fo, XI. 10. to left (heads only), ♀ Fi, XI. 8. to right. (19)



XI. 9. ♂ Fe, and XI. 10. ♂ Fo, partially coloured albinos. (20)

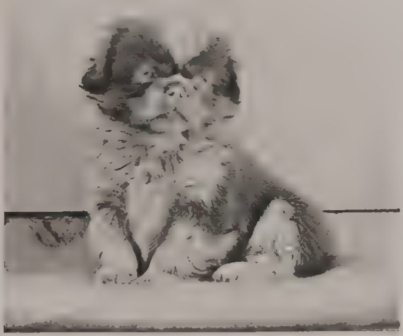


XI. 8. ♀ Fi, albino from same litter. (21)



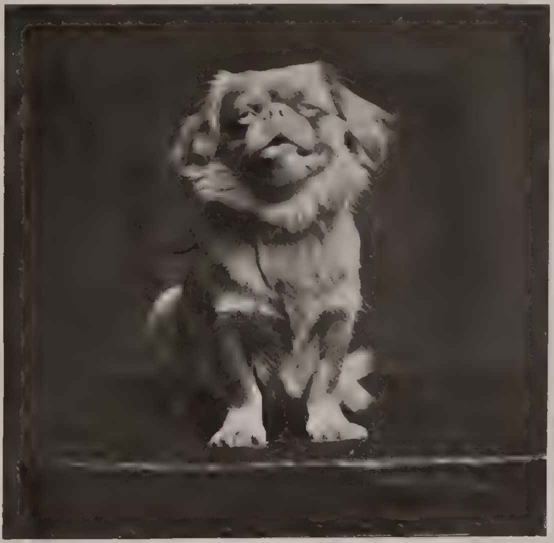
(22)

II. 7. ♂ Huangtu, imported by Mr George Brown. White coat, pigmented eyes and nose.



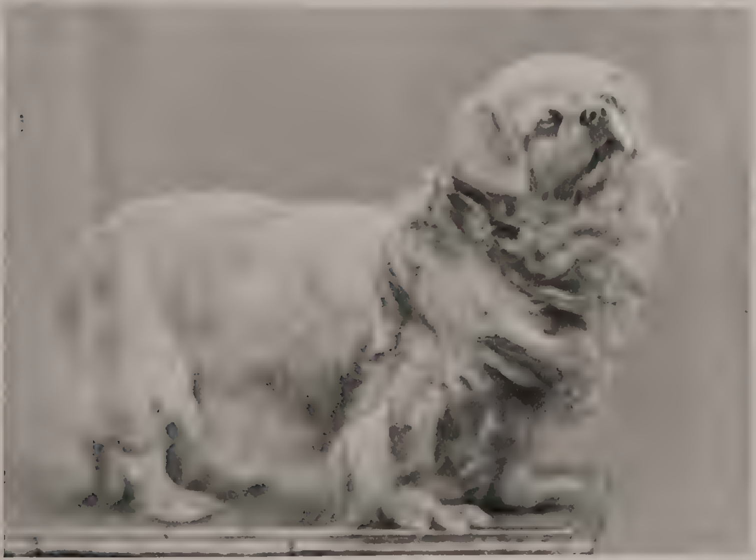
(23)

XI. 9. ♂ Fe, showing piebald characters.



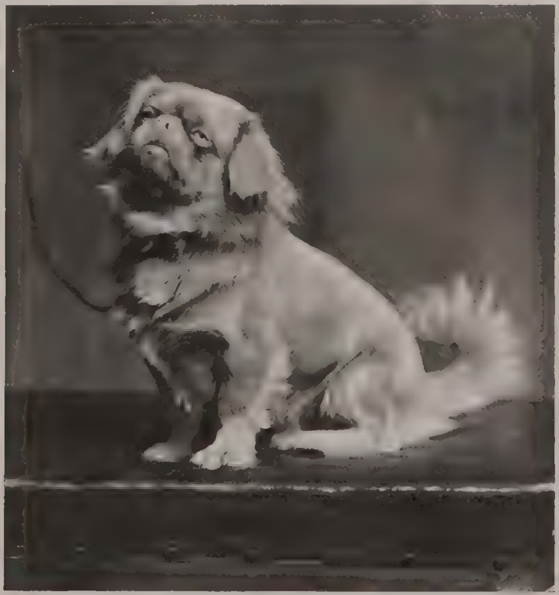
(24)

XI. 10. ♂ Fo, 20 months old, showing distribution of coloured patches.



(25)

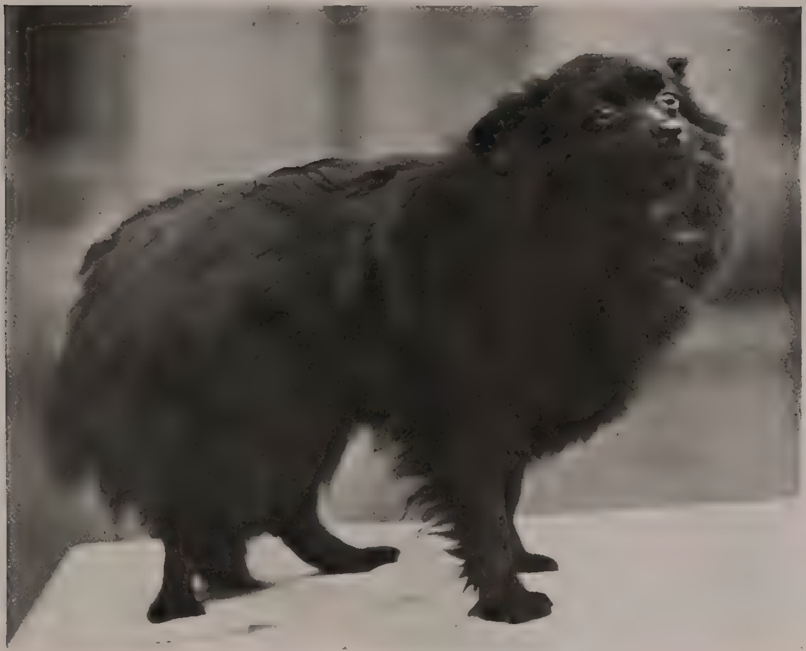
Pailu ♀, aged 15 years. Pale cream coloured, pigmented eyes and nose. Is at times paralysed in hind-quarters and rather deaf. Belonged to Mr George Brown.



(26)

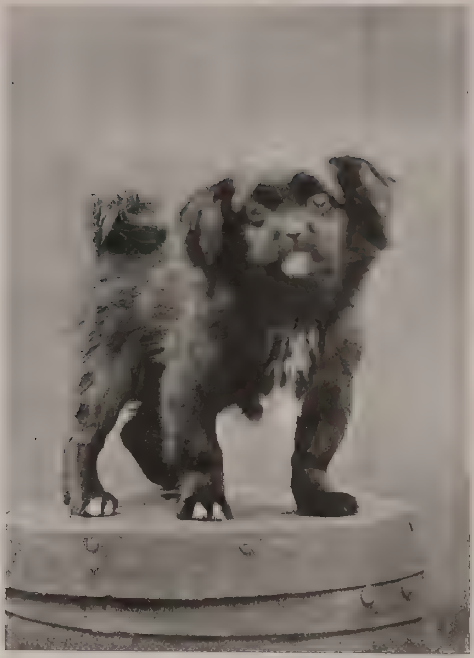
XI. 10. ♂ Fo, 20 months old, showing distribution of coloured patches.

LESS COMPLETE ALBINO PEKINESE SPANIELS.



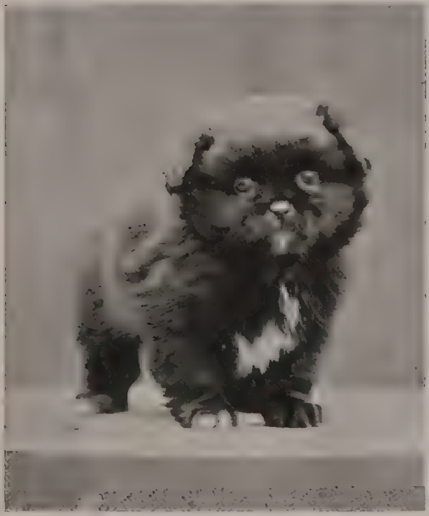
(27)

XI. 30. ♀ Olga, black Pomeranian.



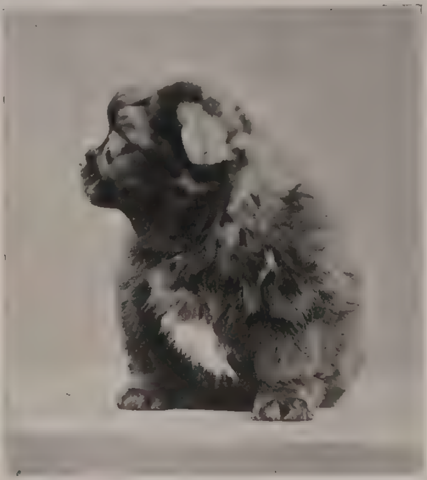
(28)

XII. 25. ♂ Ian dhu, Pompek.



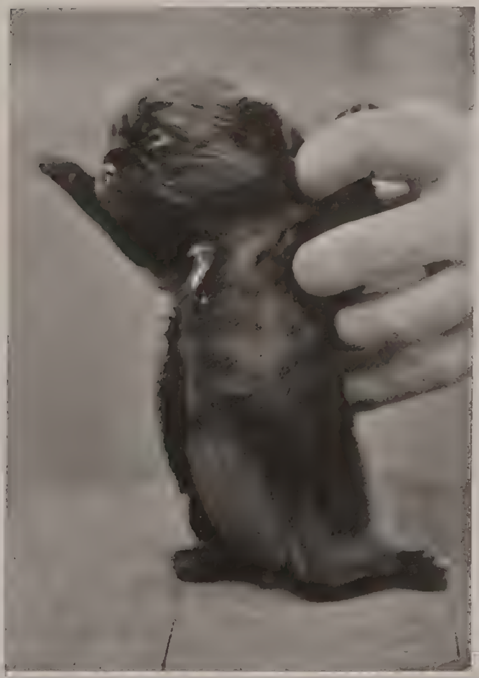
(29)

XII. 25. ♂ Ian dhu, Pompek.



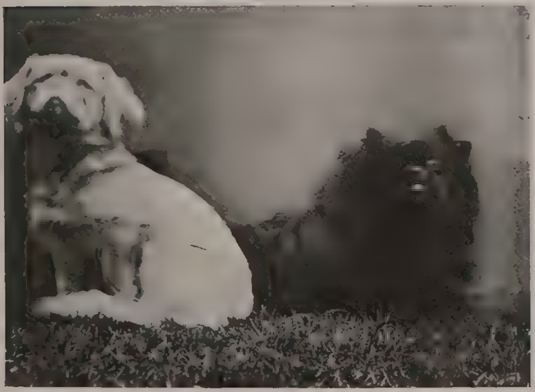
(30)

XII. 26. ♀ Mairi dhu, Pompek.



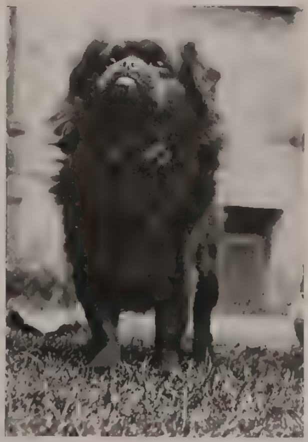
(31)

XII. 33. ♀ Yfa dhu, Pompek puppy.



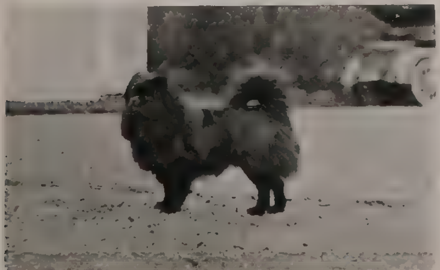
(32)

XI. 26. ♀ Mairi bhan, Dondo, and
XII. 23 ♂ Donald dhu, Pompek.



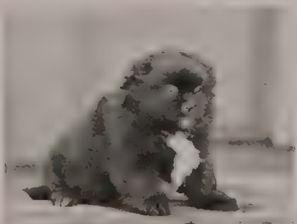
(33)

XII. 23. ♂ Donald dhu.



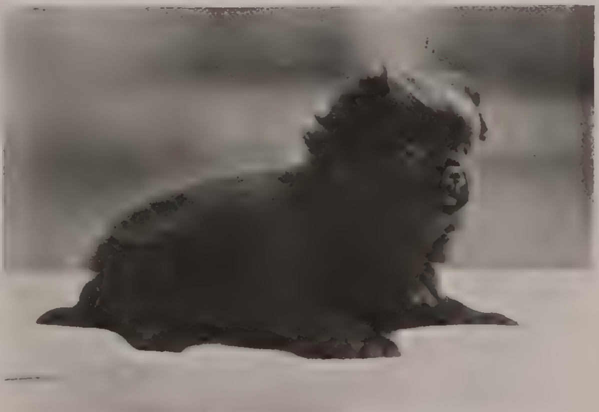
(34)

XII. 24. ♂ Dugald dhu, Pompek.



(35)

XII. 30. ♀ Buna dhu,
Pompek.

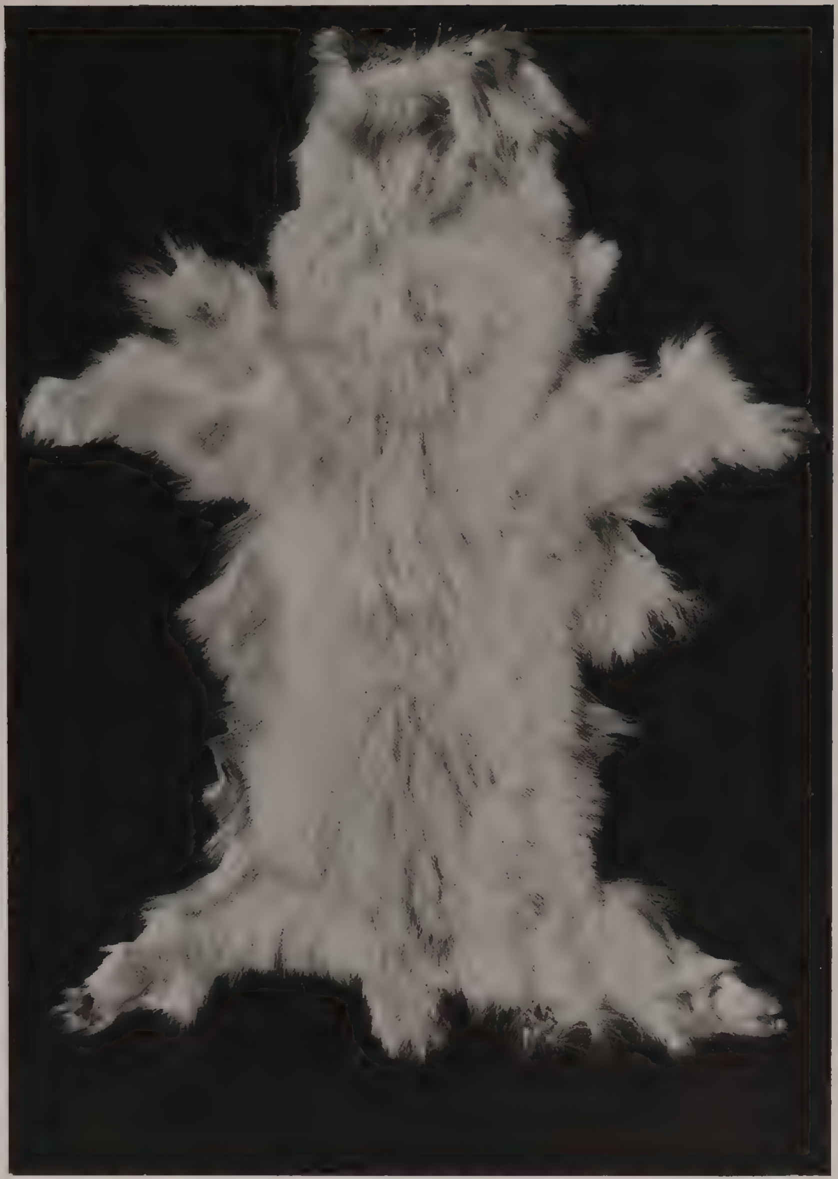


(36)

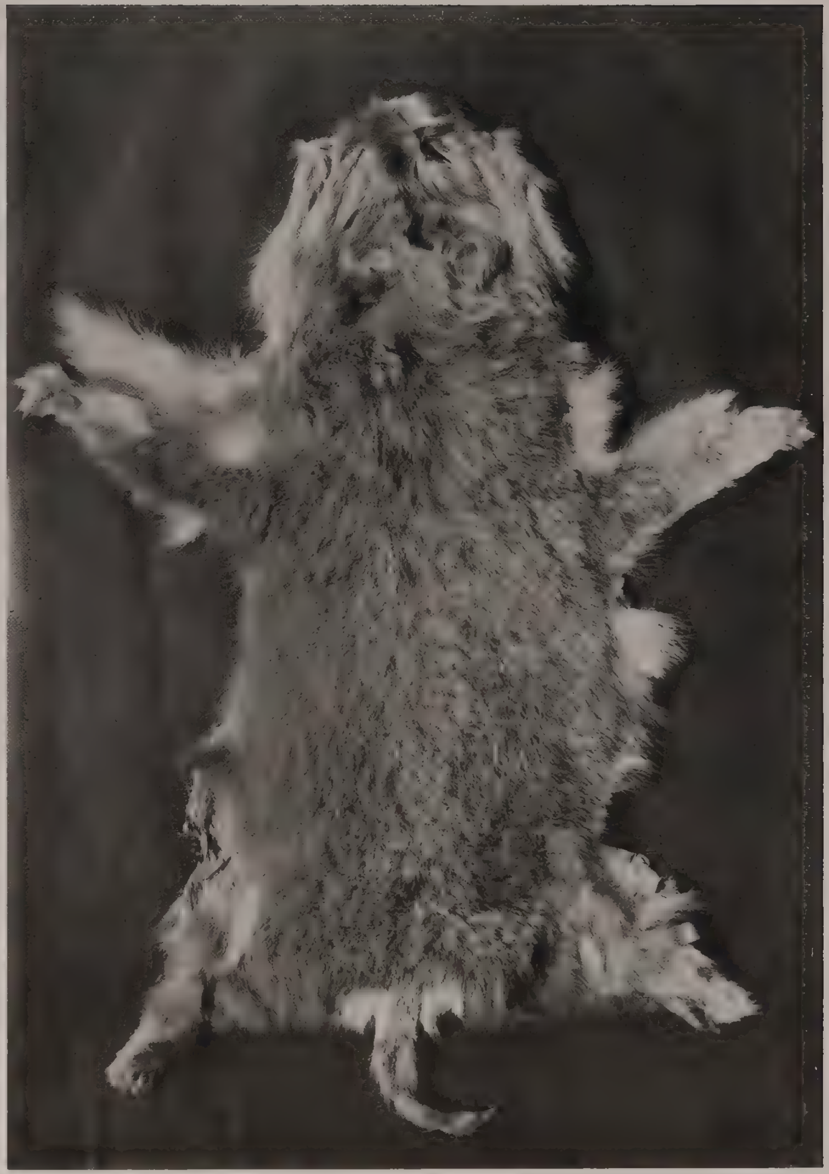
XII. 25. ♂ Ian dhu, Pompek.

POMPEKS = HYBRIDS OF ♂ DONDO AND ♀ BLACK POMERANIAN.

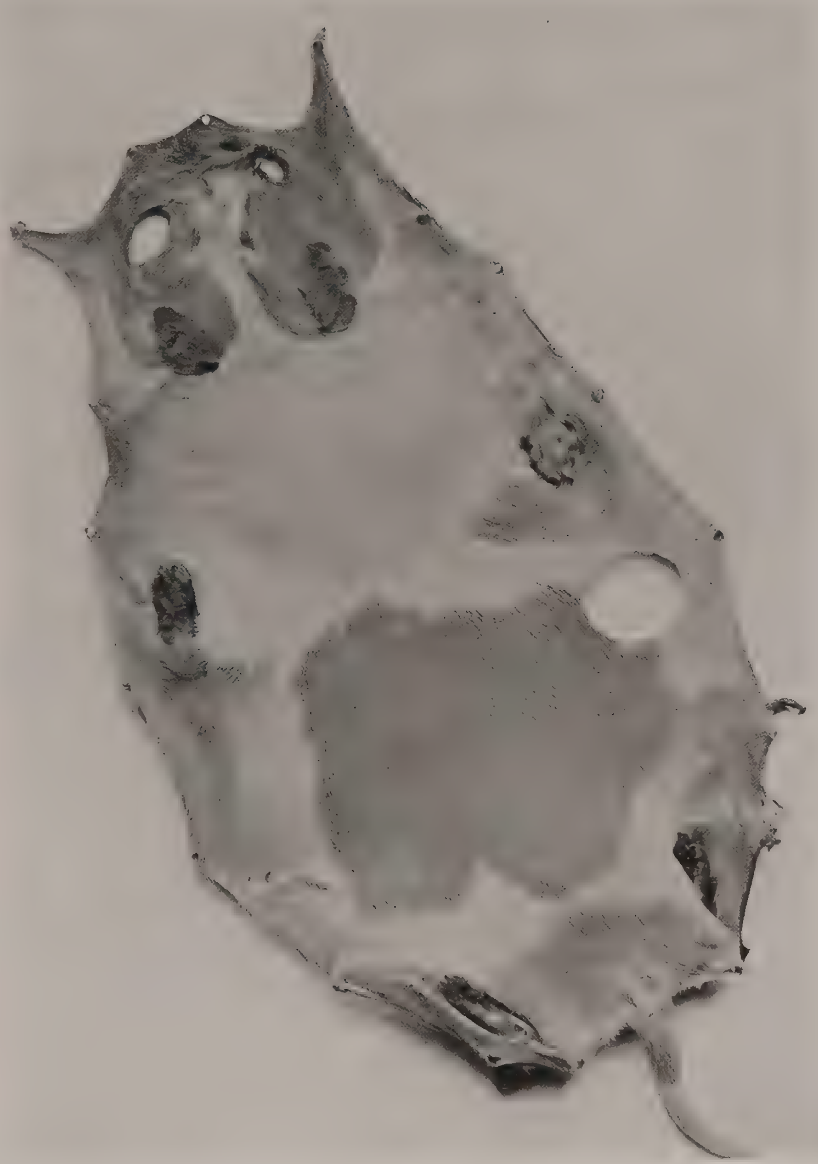
Plate ψ



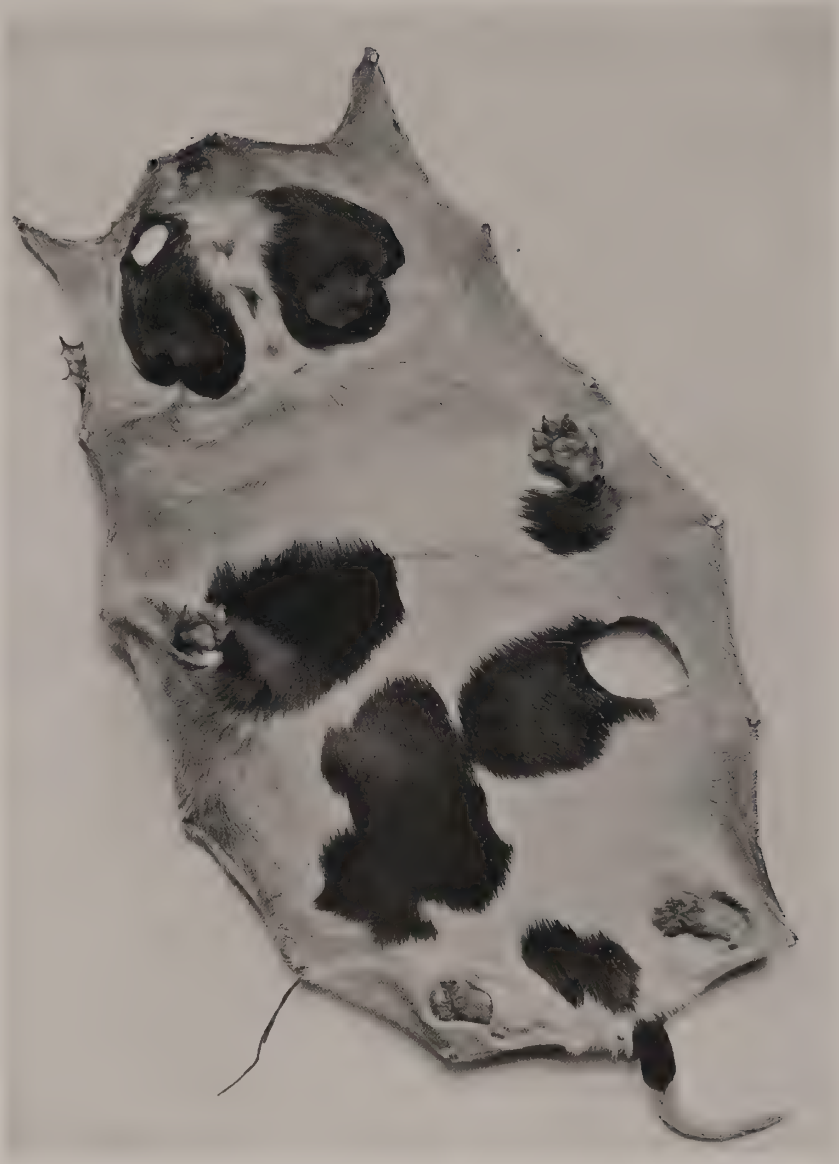
Skin of ♂ albino puppy, aged 51 days, XII. 9 of Pedigree out of Ting × Jack, both Dondos.



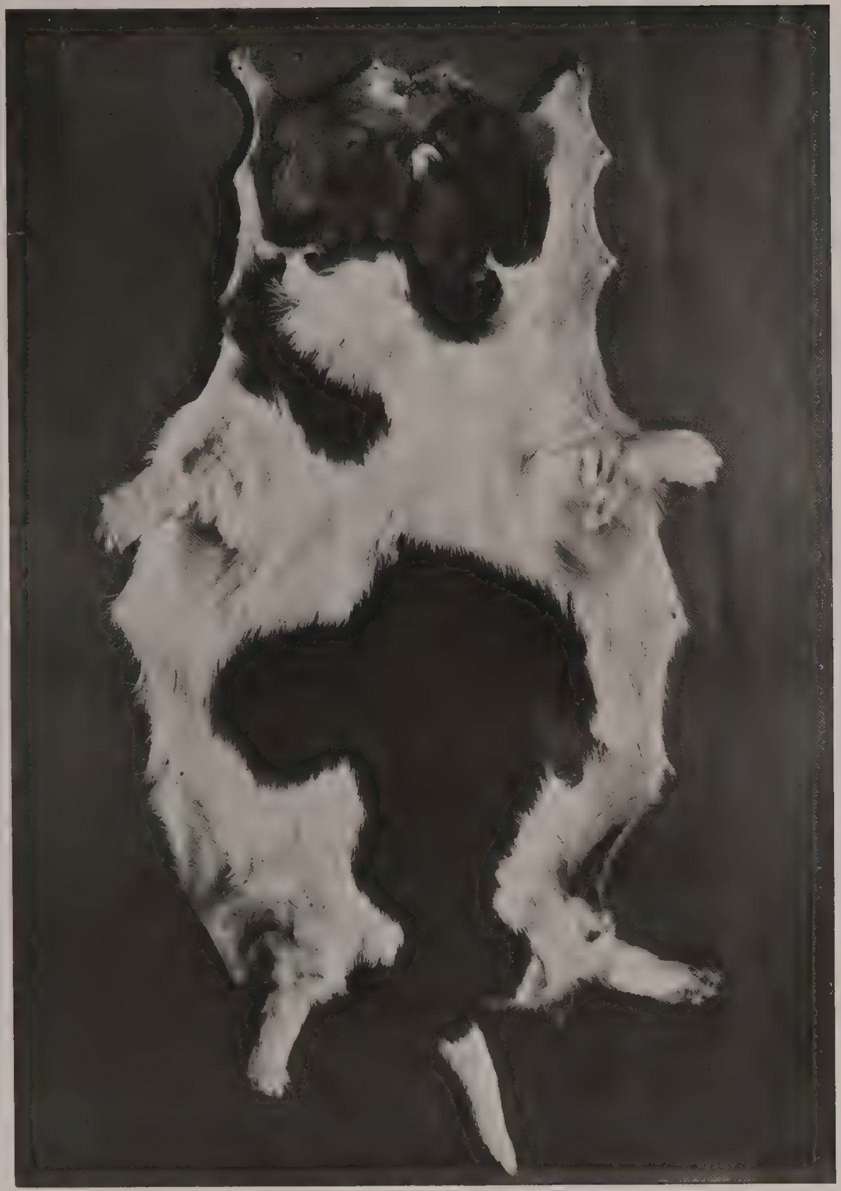
Skin of ♂ incomplete albino, aged 35 days, Fum, XI. 12 of Pedigree out of Jill × Jack, both Dondos.



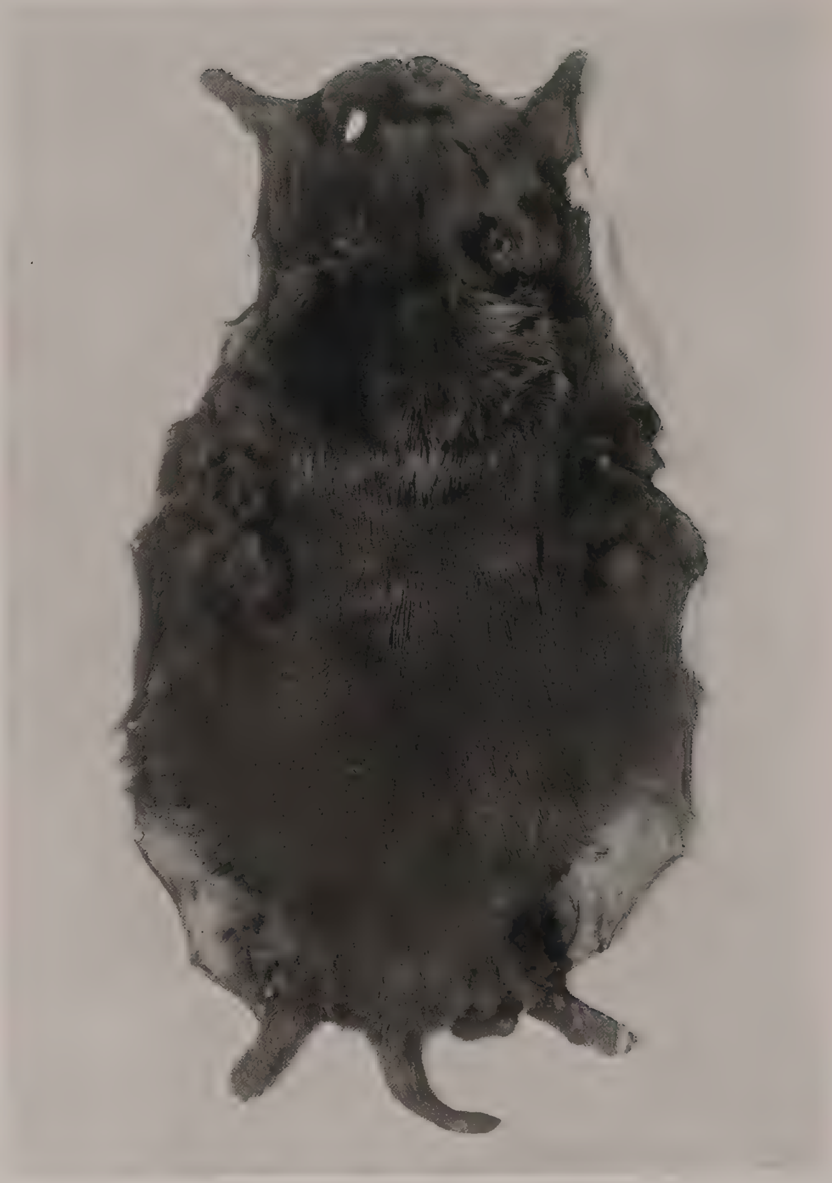
Skin of piebald puppy, aged 2 days, XIII. 15 of Pedigree, offspring of ♀ Pompek, Mairi dhu, and of ♂ Dondo, Ian ban. Patches are 'lilac' with pigment granules. Albinotic eyes with some pigment: see *Text*.



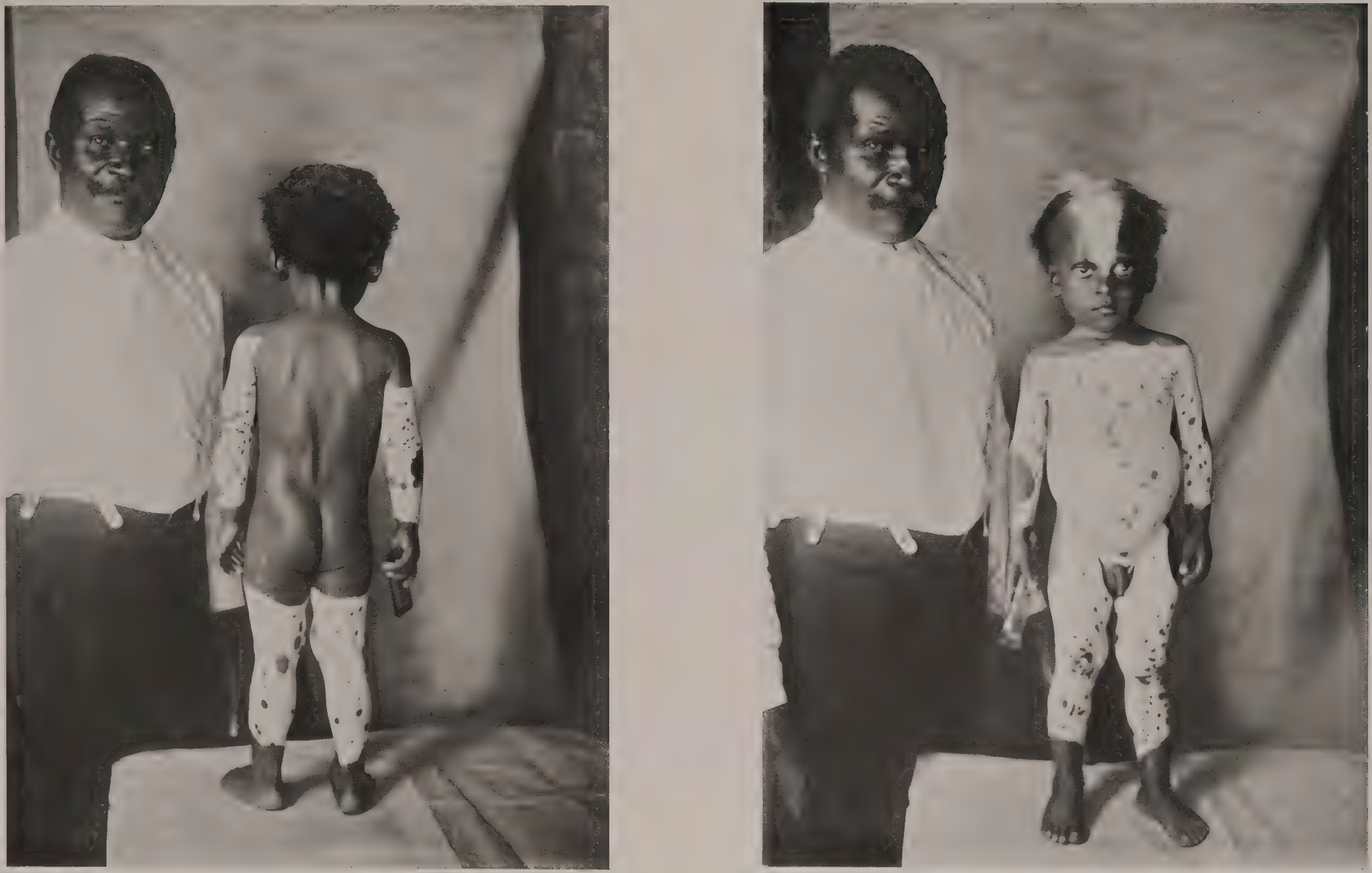
Skin of piebald puppy, aged 2 days, XIII. 13 of Pedigree, offspring of ♀ Pompek, Mairi dhu, and of ♂ Dondo, Ian ban. Eyes well pigmented. Hair densely pigmented.



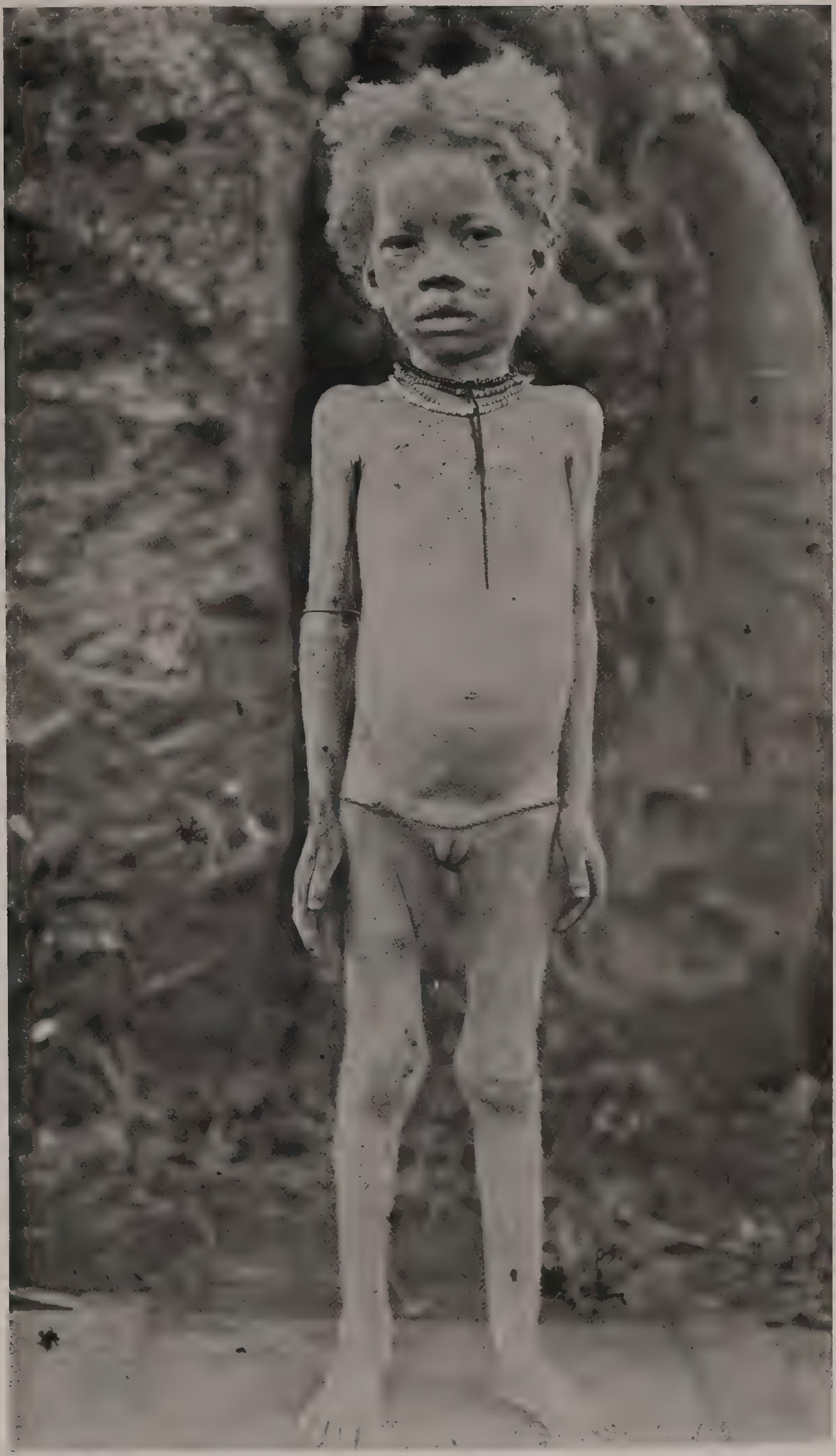
Skin of piebald puppy, aged 12 days, XIII. 14 of Pedigree, offspring of ♀ Pompek, Mairi dhu, and ♂ Dondo, Ian ban. Eyes well pigmented. Hair densely pigmented.



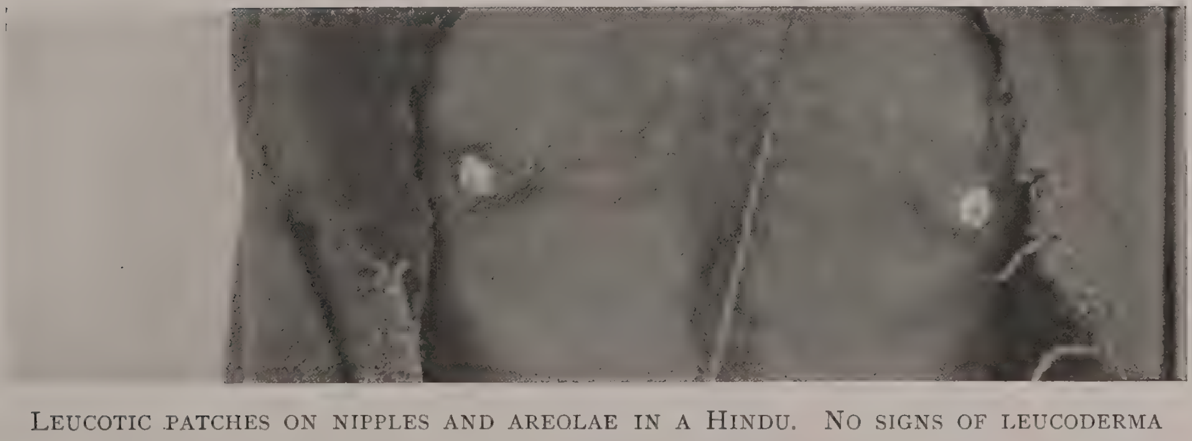
Skin of black puppy, aged 16 days, XIII. 12 of Pedigree, offspring of ♀ Pompek, Mairi dhu, and ♂ Dondo, Ian ban. Eyes well pigmented. Hair densely pigmented. (A similar puppy alone has survived out of this litter.)



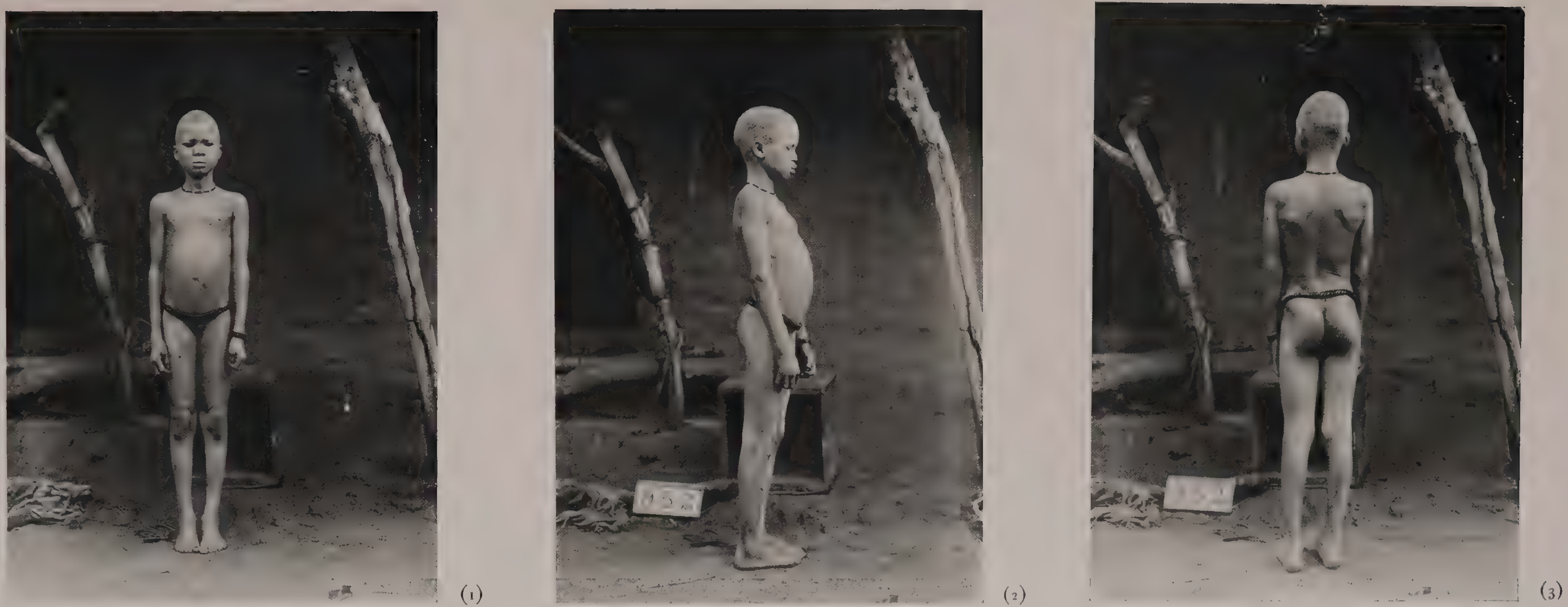
Human piebald living in El Cayo, British Honduras. We owe these photographs to the kindness of M. le Comte Maurice de Périgny. The father given in the illustrations is a pure Negro, the mother of mixed Indian and Negro blood. Lisbey, aged five, has four coffee-coloured siblings without any white spots. The first account of this piebald was published by M. le Professeur R. Blanchard, *Bulletin de la Société française d'Histoire de la Médecine*, T. ix., p. 213, Paris, 1910. This piebald is of the "classical type," and his discovery is very satisfactory, as doubt has been thrown on the existence of that type notwithstanding the paintings of such piebalds from the 18th century.



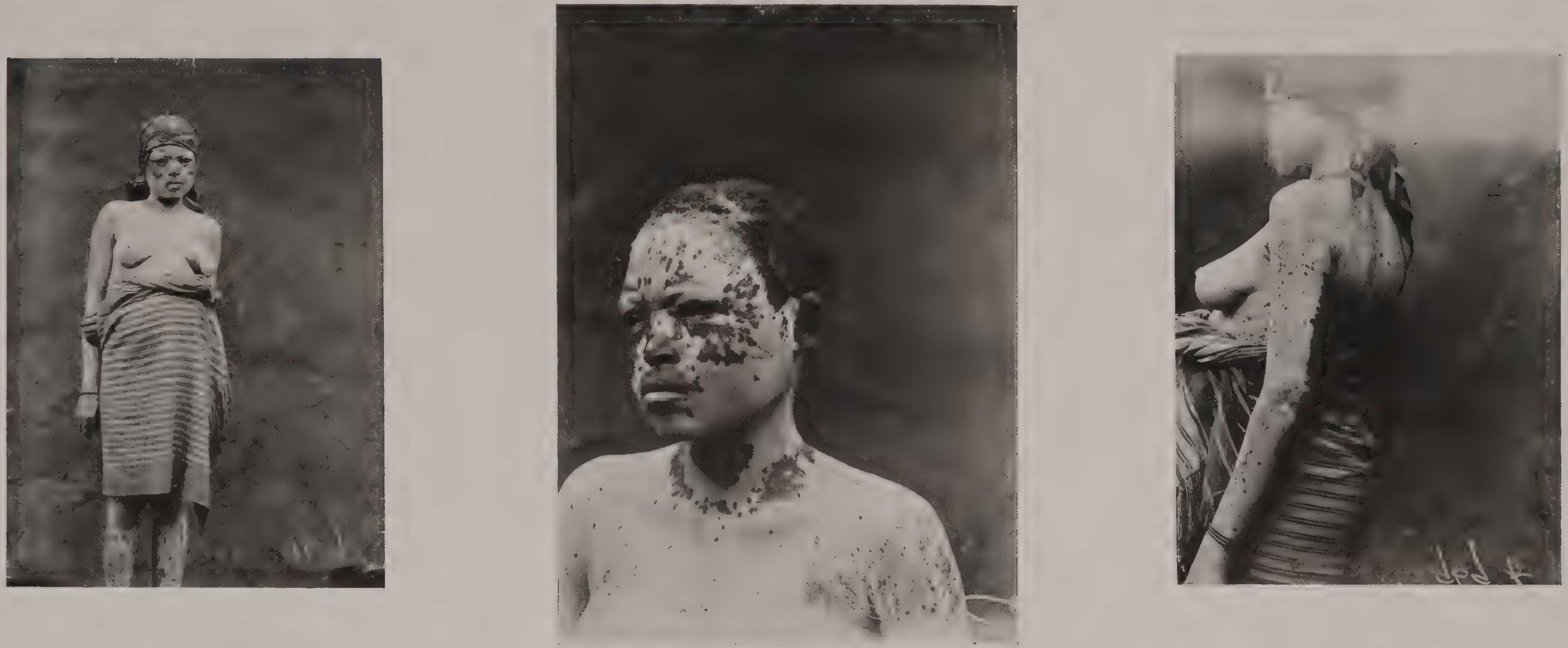
WAKAMBA ALBINO GIRL. DR ARTHUR'S CASE.



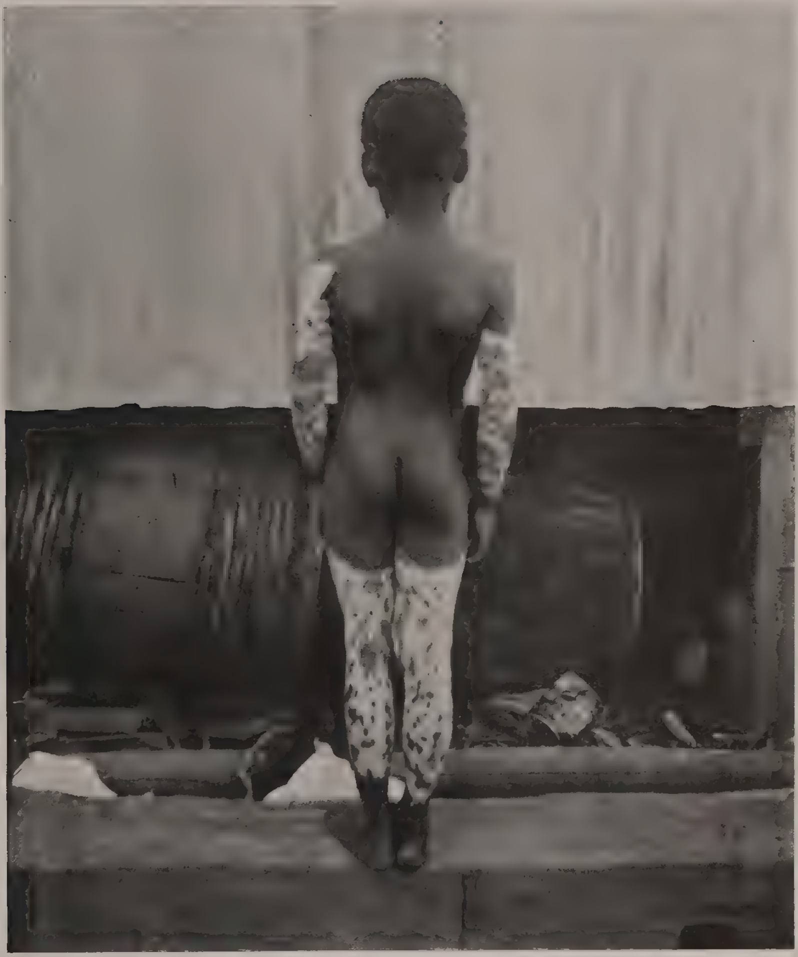
LEUCOTIC PATCHES ON NIPPLES AND AREOLAE IN A HINDU. NO SIGNS OF LEUCODERMA ELSEWHERE; SAID TO HAVE BEGUN THREE YEARS BEFORE PHOTOGRAPH WAS TAKEN. CASE DUE TO MAJOR W. F. HARVEY, I.M.S.



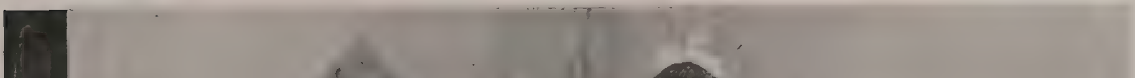
Kukumku albino girl from photographs taken by N. W. Thomas at Agbede, S. Nigeria, 1909.



Eša woman, aged 28–30; eyes normal, some gray in wool of head. The case looks like very advanced leucoderma, but the Ibo doctors described it as "congenital" (?Leucoderma starting at birth). From photographs taken at Isua, S. Nigeria, 1909, by N. W. Thomas.

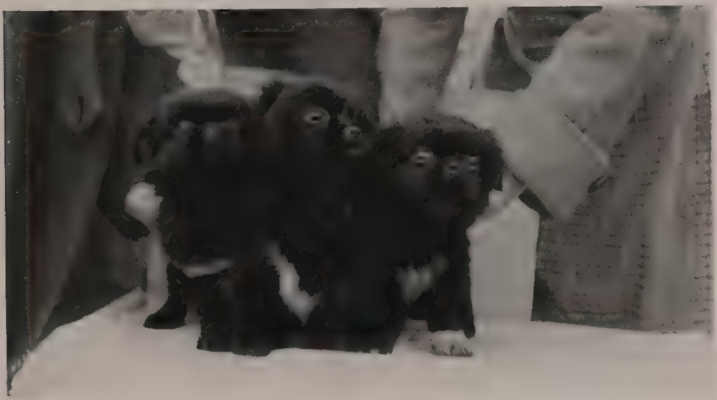


(1)

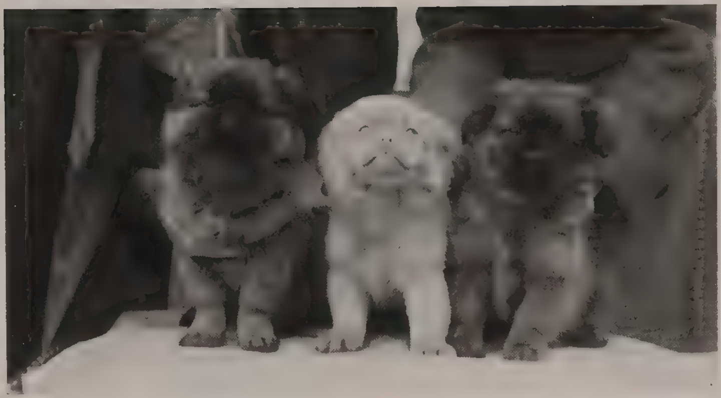


(2)

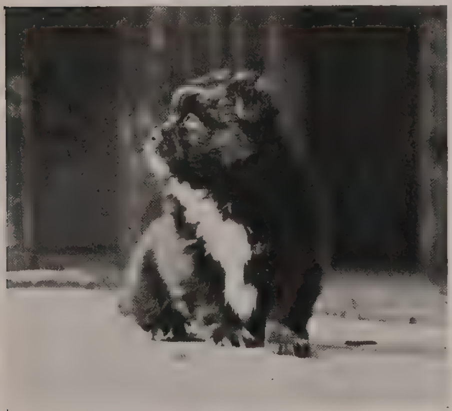
LISBEY, THE PIEBALD BOY OF EL CAYO, BRITISH HONDURAS. FROM PHOTOGRAPHS TAKEN FOR K. PEARSON, THROUGH THE COURTESY OF ROBERT H. FRANKLIN, ESQ., JULY, 1912. LISBEY'S FATHER, MOTHER, AND THREE YOUNGER SISTERS ARE SHOWN IN THE LOWER CUT.


(1)

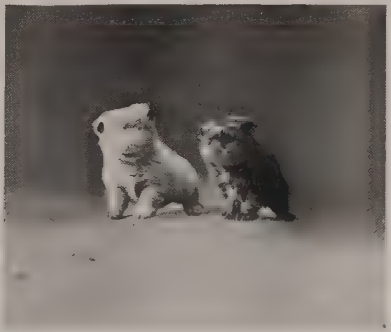
XIII. 19 ♀ Mor dhu, XIII. 20 ♀ Cilis dhu. XIII. 21 ♀ Sené dhu. Dondo × Pompek. All three typical Pompeks in coat. At three months. Litter-Siblings of XIII. 22—24.


(2)

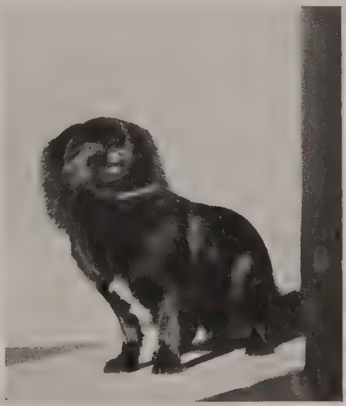
XIII. 23 ♀ Giorsal ruadh, XIII. 24 ♀ Mor bhan, XIII. 22 ♂ Donnach ruadh. Dondo × Pompek. Two sable dogs, normal Pekinese in coat, and one albino. At three months. Litter-Siblings of XIII. 19—21.


(3)

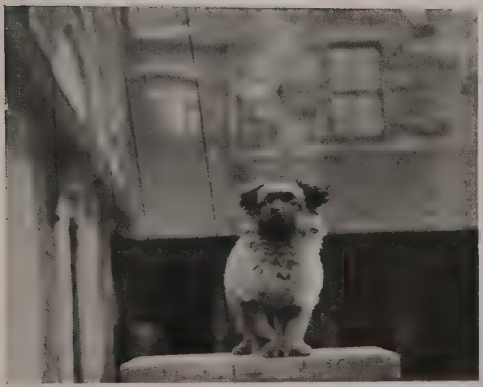
XII. 38 ♂ Fraoch dhu. Pompek. At seven weeks.


(4)

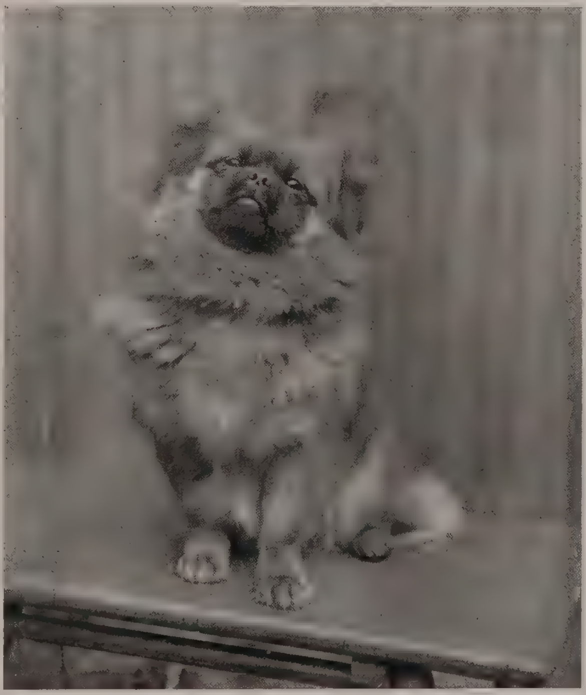
XIII. *n* ♀ Garthonzie bhan (left), XIII. *m* ♀ Cabhagach dhu (right). Dondo × Pompek. The first is an albino, the second a typical Pompek in coat. At two months.


(5)

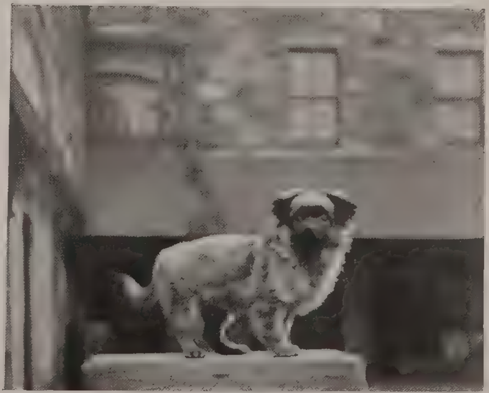
XIII. 11 ♀ Piali dhu. Dondo × Pompek. At 13 months. A dog of the same type as Cilis, *i.e.* Pompek type.


(6)

XIII. 31 ♀ Sheila, Wolf-Sable. Pompek × Pompek. A reversion to the normal Pekinese colouring. Front view. At four months. Cf. Giorsal and Donnach in (2) and (7).


(7)

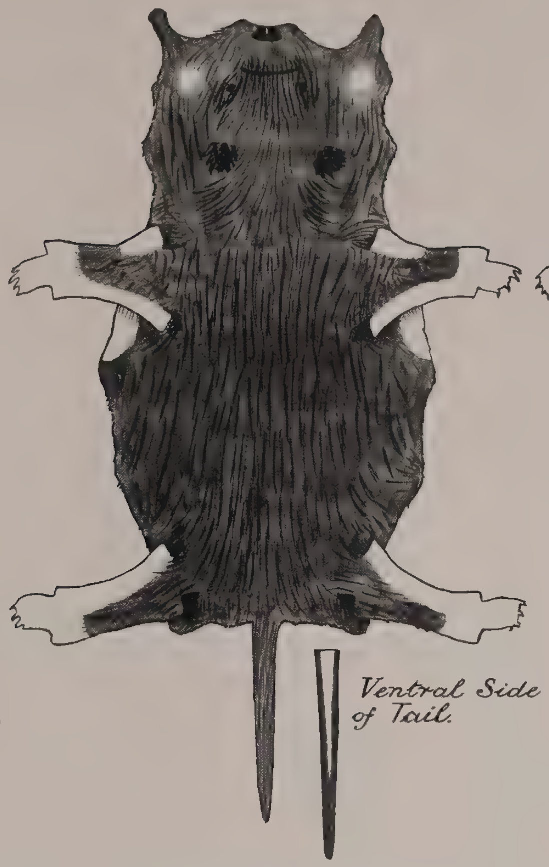
XIII 22 ♂ Donnach ruadh. Dondo × Pompek. At 10 months. Sable dog, *i.e.* yellow-red and black hairs mixed.


(8)

XIII. 31 ♀ Sheila, Wolf-Sable. Pompek × Pompek. A reversion to the normal Pekinese colouring. Side view. At four months. Cf. Giorsal and Donnach in (2) and (7).

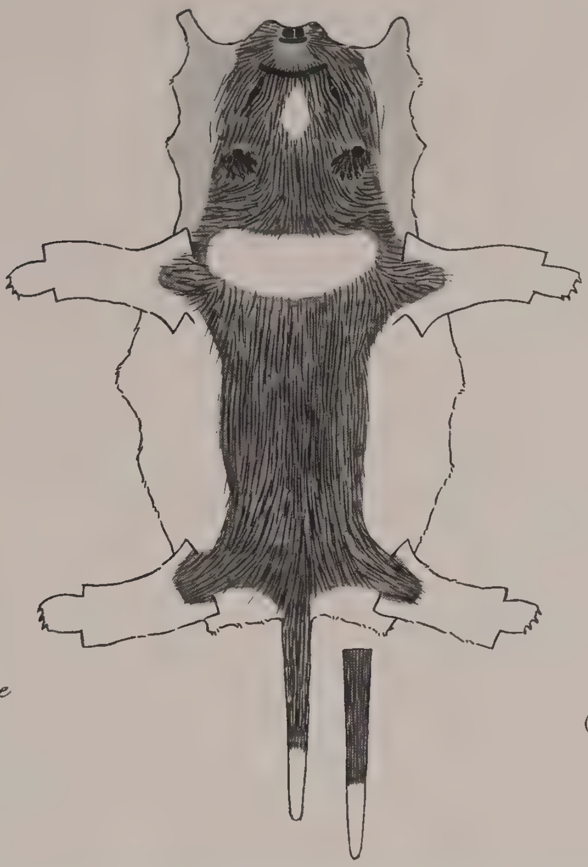
Dondo and Pomeranian Hybrids.

Schematic Distribution of Coloured Parts of Coat.



(1)

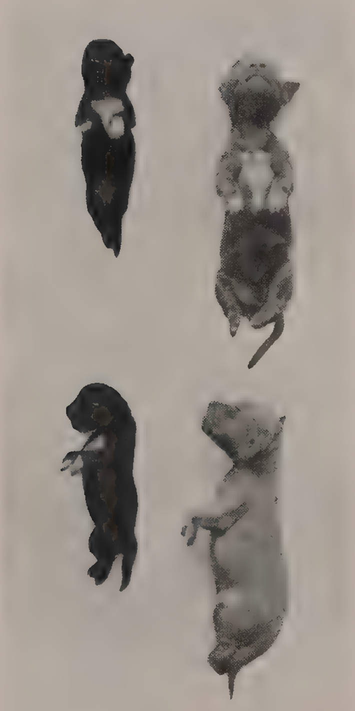
XI. 10 Fo I. The shaded parts in these figures are pale yellowish brown or light fawn.



(2)

XI. 9 Fe. Distribution of colour at six months. Chest not quite white. Colour as Fo I.

Skewbald Puppies from Dondo × Dondo.



(3).

XIII. 30 Pompek × Pompek (left), Typical Pompek. XIII. 32 Pompek × Pompek (right). Extracted but incomplete albino. Coat: "lilac" with white shirt front; eyes: Dondo albinism.

(4)

XIII. 29 Pompek × Pompek. Litter-sibling of XIII. 25—28. Typical Pompek, but nose differentiated from rest of litter. Cf. this Plate (5).

(5)

XIII. 25—28 Pompek × Pompek. Litter-siblings of XIII. 29. All typical Pompeks with slight tinge of red in some of the coats.

Dondo and Pomeranian Hybrids.

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